DOCUMENT RESUME

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TITLE	Military Curricula for Vocational & Technical Education. Metals Processing Specialist, Blocks I and II, Classroom Course 13-5.
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IDENTIFIERS	Military Curriculum Project

ABSTRACT

These curriculum materials are the first section of a four-part, secondary-postsecondary-level course in metals processing. The course is one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. Block I, Introduction to Oxyacetylene Welding, contains seven lessons covering fifty-four hours of instruction: Shop and Flight Line Safety Practices, Hand Tools, Operation and Maintenance of Welding Equipment, Bead and Lap Joints of Carbon Steel, Butt Joints of Carbon Steel, Tee Joints of Carbon Steel, and Position Welding. Block II, Oxyacetylene Welding, Cutting, Soldering, Brazing, and Hard Surfacing, contains seven lessons covering forty hours of instruction: Mechanical Drawing and Blueprint Reading, Joints of Heat and Corrosion Resistant Ferrous Alloys, Cutting Carbon Steel, Silver and Lead Soldering, Brazing Steel and Gray Iron Castings, Fusion Welding Ferrous Castings, and Hard Surfacing. Instructor materials include a course chart, detailed lesson plans, and a plan of instruction containing the units of instruction, criterion objectives, and additional materials needed. Student materials include a study guide for each block with objectives, information, review exercises, and references for each lesson; programmed text on shop safety; handout of glossary welding terms; and handout bibliographies. Suggested audiovisuals are not provided. (YLB)

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Military Curricula for Vocational & Technical Education

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
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EDUCATION

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METALS PROCESSING SPECIALIST
BLOCKS I & II

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY

CE 024 394

This military technical training course has been selected and adapted by The Center for Vocational Education for "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education," a project sponsored by the Bureau of Occupational and Adult Education, U.S. Department of Health, Education, and Welfare.

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL
Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
The Ohio State University · 1960 Kenny Road · Columbus, Ohio 43210
Tel (614) 486-3655 Cable CTVOCEDOSU/Columbus, Ohio

Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

METALS PROCESSING SPECIALIST, BLOCKS I AND II

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Block II - Oxyacetylene Welding, Cutting, Soldering, Brazing And Hard Surfacing

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Shop Safety - Programmed Text Page 278

Bibliography - Handout Page 318

Glossary of Terms - Handout Page 328

METALS PROCESSING SPECIALIST, BLOCKS I AND II

Classroom Course

Developed by:

United States Air Force

Development and
Review Dates

September 23, 1975

Occupational Area:

Machine Shop

Target Audiences:

Grades 11-adult

Print Pages:

343

Cost:

$7.00

Availability:

Military Curriculum Project, The Center
for Vocational Education, 1960 Kenny
Rd., Columbus, OH 43210

Contents:	Type of Materials:						Instructional Design:				Type of Instruction:	
	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Group Instruction:	Individualized:
Block I												
Introduction to Oxyacetylene Welding	●	●		●	●	★	●	★	●	★	●	●
Block II												
Oxyacetylene Welding, Cutting, Soldering, Brazing, and Hard Surfacing	●				●	★	●	★	●	★	●	

★ Materials are recommended but not provided.

THE CENTER FOR VOCATIONAL EDUCATION

Expires July 1, 1978

Course Description

This is the first section of a four-part course on metals processing. Training for the entire course includes fabrication of welded structures and metal weld repairs; principles, techniques and processes of welding, cutting, soldering, brazing, and hard surfacing of various types of metals used in fabrication and repair of equipment; blueprint reading; heat treating, hardness testing, identification and prevention of corrosion; use of hand and measuring tools; and operation and maintenance of welding, heat treating, test equipment and power machinery such as grinders, drill presses, power saws, and metal cutting shears. Safety is emphasized throughout the course. **Metal Processing Specialist, Blocks I and II** deals with oxyacetylene welding, cutting, soldering, brazing, and hard surfacing. Two blocks cover 94 hours of instruction.

Block I — *Introduction to Oxyacetylene Welding* contains seven lessons covering 54 hours of instruction. Three lessons on the course orientation, Air Force career ladder and communications security were deleted. The remaining lessons and respective hours follow:

- Shop and Flight Line Safety Practices (1 hour)
- Hand Tools (1 hour)
- Operation and Maintenance of Welding Equipment (4 hours)
- Beads and Lap Joints of Carbon Steel (12 hours)
- Butt Joints of Carbon Steel (12 hours)
- Tee Joints of Carbon Steel (12 hours)
- Position Welding (12 horus)

Block II — *Oxycetylene Welding, Cutting, Soldering, Brazing, and Hard Surfacing* contains seven lessons covering 40 hours of instruction. Three additional lessons on Air Force Technical Orders, supply systems, and inspection and maintenance were deleted.

- Mechanical Drawing and Blueprint Reading (8 hours)
- Joints of Heat and Corrosion Resistant Ferrous Alloys (7 hours)
- Cutting Carbon Steel (6 hours)
- Silver and Lead Soldering (3 hours)
- Brazing Steel and Gray Iron Castings (7 hours)
- Fusion Welding Ferrous Castings (6 hours)
- Hard Surfacing (3 hours)

This section contains both teacher and student materials. Printed instructor materials include a course chart; detailed lesson plans; and a plan of instruction including the units of instruction, criterion objectives, the duration of the lessons, and additional materials needed. Student materials include a study guide for each block which includes objectives, information, review exercises, and references for each lesson; a programmed text on shop safety; a handout of glossary welding terms; and a handout bibliography.

Text materials are provided in the study guides, however, several commercial texts and military technical manuals are referenced throughout the course. These are not provided. Audiovisuals suggested for use in the entire course include 188 slides, 8 films, 2 videotapes, and 9 transparency sets. Audiovisuals are not provided.

POT 3ABR53131
(PDS Code APJ)

PLAN OF INSTRUCTION
(Technical Training)

METALS PROCESSING SPECIALIST

AIR TRAINING COMMAND

13-5

CHANUTE TECHNICAL TRAINING CENTER

23 September 1975 - Effective 23 September 1975 with Class 750923

4.

LIST OF CURRENT PAGES

This POI consists of 68 current pages issued as follows:

Page No.	Issue
Title	Original
A	Original
i	Original
ii	Original
1 thru 55	Original
A1-1 thru A1-9	Original

DISTRIBUTION: ATC/TTMS-1, AULD-1, TWS-60, TTVGC-3, TTOT-1, TTOXW-1, TTOR-1, TTE-1, CCAF/AY-2

COURSE CHART

NUMBER 3ABR53131	PDS CODE APJ	DATE 15 July 1975
URSE TITLE Metals Processing Specialist		
ATC OPR AND APPROVAL DATE TTMS, 6 Nov 1972	CENTER OPR Chanute/TTOXW	SUPERSEDES COURSE CHART 3ABR53131, 2 June 1975
DEPARTMENT OPR Department of Weapon Systems Support Training		APPLICABLE TRAINING STANDARD STS 531X1, 31 May 75
LOCATION OF TRAINING Chanute AFB, Illinois 61868		COURSE SECURITY CLASSIFICATION UNCLASSIFIED
INSTRUCTIONAL DESIGN Group/Lock Step		TARGET READING GRADE LEVEL FOR PREPARATION OF TRAINING LITERATURE 8

LENGTH OF TRAINING

(15 Weeks, 0 Days)

	Hours	
Technical Training (TT)		550
Classroom/Laborabory (C/L)	450	
Complementary Technical Training (CTT)	100	
Related Training (RT)		50
Standard Traffic Safety Course (Course VII) (AFR 50-24)	12	
Local Conditions Course (Course II) (AFR 50-24)	2	
Supplemental Military Training (SMT) (ATCM 50-20)	20	
Sq Commander's Call/Briefings (safety, security, WAPS, UCMJ briefings)	6	
End of Course Appointments, Predeparture Safety Briefing	10	
TOTAL		600

MARKS

Effective Date: 23 September 1975 with Class 750923

TABLE I - MAJOR ITEMS OF EQUIPMENT

Trainers: Demonstrator, Gas Welding 3217, Steel Tubing Welding 3216, Electrical 3219, Electric Welding 3218, Jet Engine Repair 3215, Welding Torches 2967, Spark Tester 4047, Oxyacetylene Cutting Applications 4408, Tungsten Inert Gas (TIG) Shielded Welding Specimens 4404, Hard and Soft Solder Joints 4406.

Training Equipment: Electric Arc Welding Machines, Spot and Foil Resistance Welders, Oxyacetylene Welding Equipment, Metal Cutter Power Shears, Power Saws, Inert Gas Shielded Arc Welding Equipment, Rectangular Dri Bel Bubble, Pedestal Grinders and Buffers, Metal Cleaning Equipment, Heat Treating Furnaces, Sand Blasting Machine, Drill Presses, Former-Slip Roll, Hardness Testing Machines, and Tensile Testing Machine.

ATC FORM DEC 74 449 REPLACES PREVIOUS EDITIONS AND ATC FORM 449 B, NOV 72

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COURSE CHART – TABLE II – TRAINING CONTENT

NOTE: Include time spent on technical training (TT) (classroom/laboratory (C/L) and complementary technical training (CTTI)) and related training (RT). Exclude time spent on individual assistance (remedial instruction). A single entry of time shown for a unit is C/L time. When a double entry is shown, the second entry is CTT time.

WK OF TNG \ HRS PER DAY	1 2 3 4 5 6	7 8
1 2	Course Material - UNCLASSIFIED — 60 Hours TT BLOCK I - Introduction to Oxyacetylene Welding Orientation and Study Skills (2 hrs); Metals Processing Career Ladder (1 hr); Communications Security (1 hr); Shop and Flight Line Safety Practices (1 hr); Hand Tools (1 hr); Operation and Maintenance of Welding Equipment (4 hrs); Beads and Lap Joints of Carbon Steel (12 hrs); Butt Joints of Carbon Steel (12 hrs); Tee Joints of Carbon Steel (12 hrs); Position Welding (12 hrs); Measurement and Critique (2 hrs). (Equipment Hazards and Personnel Safety Integrated with Above Subjects) 60 Hours C/L	20 Hours RT
3 4	Course Material - UNCLASSIFIED — 64 Hours TT BLOCK II - Oxyacetylene Welding, Cutting, Soldering, Brazing, and Hard Surfacing Mechanical Drawing and Blueprint Reading (8 hrs); Joints of Heat and Corrosion Resistant Ferrous Alloys (7 hrs); Air Force Technical Orders (8 hrs); Cutting Carbon Steel (6 hrs); Silver and Lead Soldering (3 hrs); Air Force Supply System (4 hrs); USAF Inspection and Maintenance System (6 hrs); Brazing Steel and Gray Iron Castings (7 hrs), Fusion Welding Ferrous Castings (6 hrs); Hard Surfacing (3 hrs); Measurement and Critique (2 hrs). (Equipment Hazards and Personnel Safety Integrated with Above Subjects) 60 Hours C/L	16 Hours RT 4 Hours CTT

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MODIFICATIONS

Pages 1-7 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
9. Tee Joints of Carbon Steel a. Given oxyacetylene welding equipment and carbon steel specimens, set up and weld tee joints in the flat position, free of undercut, overlap, excessive penetration, and oxidation for a total combined distance of no less than 3/4 of the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.	12	Column 1 Reference 9a STS Reference 3a, 3b, 11e Instructional Materials 3ABR53131-SG-109, Tee Joints of Carbon Steel TO 34W4-1-5 Modern Welding (Chapter 1) Training Equipment Stationary Oxyacetylene Welding Equipment, Complete (1) Trainer: 3217, Oxyacetylene Welded Joints (12) Power Shears (6) Toolkit (1) Training Methods Discussion/Demonstration (2 hrs) Performance (10 hrs) Instructional Environment/Design Classroom (1 hr) Laboratory (11 hrs) Instructional Guidance Emphasize welding safety and fire prevention procedures. Explain welding requirements for tee joints and joint set-up procedures. Instruct student to make maximum use of metal coupons.

PLAN OF INSTRUCTION NO. 3ABR53131	DATE 23 September 1975	BLOCK NO. I	PAGE NO. 8

ATC FORM 337A

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☆ U.S. GPO: 1973—779-403/139

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
10. Position Welding a. Given oxyacetylene welding equipment and carbon steel specimens, set up and make fillet welds in the horizontal position, free of undercut, overlap, and excessive oxidation, for a total combined distance of no less than 3/4 of the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed. b. Given oxyacetylene welding equipment and carbon steel specimens, set up and make fillet welds in the vertical position, free of undercut, overlap, and excessive oxidation for a total combined distance of no less than 3/4 of the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish.	12	Column 1 Reference — STS Reference 10a — 3a, 3b, 11f 10b — 3a, 3b, 11f Instructional Materials 3ABR531313-SG-110, Position Welding TO 34W4-1-5 Modern Welding (Chapter 1) Training Equipment Stationary Oxyacetylene Welding Equipment, Complete (1) Trainer: 3217, Oxyacetylene Welded Joints (12) Power Shears (6) Toolkit (1) Training Methods Discussion/Demonstration (2 hrs) Performance (10 hrs) Instructional Environment/Design Classroom (1 hr) Laboratory (11 hrs) Instructional Guidance Emphasize welding safety applicable to position welding. Explain welding requirements for fillet welds. Explain joint set-up, flame adjustment, torch angles, and molten pool control. Emphasize proper joint set-up to conserve filler rods and gases.
11. Related Training (identified in course chart).	20	
12. Measurement and Critique	2	

PLAN OF INSTRUCTION NO. 3ABR53131	DATE 23 September 1975	BLOCK NO. I	PAGE NO. 9

PLAN OF INSTRUCTION	COURSE TITLE Metals Processing Specialist

BLOCK TITLE

Oxyacetylene Welding, Cutting, Soldering, Brazing, and Hard Surfacing

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2
1. Mechanical Drawing and Blueprint Reading	8
a. Given shop drawings, diagrams, and blueprints, identify and interpret the dimensions for each with 75% accuracy.	(2)
b. Given drawing materials and 3ABR53131-SG-201, make shop drawings and sketches of welded assemblies. Drawings must be within 1/32 inch of study guide dimensions.	(6)

SUPPORT MATERIALS AND GUIDANCE 3

Column 1 Reference	STS Reference
1a	12a
1b	12b

Instructional Materials
3ABR53131-SG-201, Mechanical Drawing and Blueprint Reading

Audio Visual Aids
Blueprint: TA-36, Mobile Filing Cabinet
Charts, Mechanical Drawing

Training Equipment
Drawing Equipment (1)

Training Methods
Discussion/Demonstration (2 hrs)
Performance (6 hrs)

Instructional Environment/Design
Classroom (.5 hr)
Laboratory (7.5 hrs)

Instructional Guidance
Emphasize the importance of shop drawings to the welder and have each student complete the station joint shown in 3ABR53131-SG-201. Have each student correctly interpret each part of the drawing. Caution students not to mark or write on any training literature as it is to be reused by subsequent classes. Conserve drawing paper, pencils, and erasers.

PLAN OF INSTRUCTION NO. 3ABR53131	DATE 23 September 1975	BLOCK NO. II	PAGE NO. 11

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
2. Joints of Heat and Corrosion Resistant Ferrous Alloys	7	Column 1 Reference — STS Reference 2a — 13a 2b — 3a, 3b, 13b 2c — 3a, 3b, 13c 2d — 3a, 3b, 13d Instructional Materials 3ABR53131-SG-202, Joints of Heat and Corrosion Resistant Ferrous Alloys TO 34W4-1-5, Welding Theory and Application Modern Welding (Chapter 18) TO 1-1A-9, Aerospace Metals - General Data and Usage Factors Audio Visual Aids Slides: Stainless Steel Joint Preparation Transparencies: Stainless Steel Joint Preparation Training Equipment Oxyacetylene Welding Station Complete (1) Power Shears (6) Toolkit (1) Training Methods Discussion/Demonstration (2 hrs) Performance (5 hrs) Instructional Environment/Design Classroom (1 hr) Laboratory (6 hrs) Instructional Guidance Have each student respond to all written items in the lesson. Stress shop safety and fire prevention. Discuss the procedures for welding lap, butt, and tee joints of heat and corrosion resistant ferrous alloys. Emphasize conservation of metal, filler rods, and welding gases.
a. Without reference, identify the types and uses of heat and corrosion resistant ferrous alloys with 75% accuracy.	(.5)	
b. Given oxyacetylene welding equipment, and heat and corrosion resistant ferrous alloy specimens, set up and weld lap joints, free of undercut, oxidation, overlap, and excessive penetration for a total combined distance of no less than 3/4 of the length of the specimen excluding the first 1/2 inch start and the last 1/2 finish. All shop safety, good housekeeping, and fire prevention measures must be observed.	(1.5)	
c. Given oxyacetylene welding equipment and heat and corrosion resistant ferrous alloy specimens, set up and weld butt joints with 100% penetration, free of undercut, overlap, and excessive oxidation for a total combined distance of no less than 3/4 of the specimen excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures **must be observed.**	(3)	
d. Given oxyacetylene welding equipment, and heat and corrosion resistant ferrous alloy specimens, set up and weld tee joints free of undercut, overlap, and excessive penetration for a total combined distance of no less than 3/4 of the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.	(2)	

PLAN OF INSTRUCTION NO. 3ABR53131	DATE 23 September 1975	BLOCK NO. II	PAGE NO. 12

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)
3. Air Force Technical Orders	8
a. Without reference, identify the purpose, scope, and application of USAF technical orders with 75% accuracy.	(.5)
b. Given technical orders and indexes, locate specific items. Two of the three items must be located correctly.	(4)
c. Given technical orders, read and interpret technical order maintenance drawings and diagrams. Two of three items must be correctly read and interpreted.	(3)
d. Without reference, identify procedures for initiating TO improvement reports.	(.5)

Omit

3 SUPPORT MATERIALS AND GUIDANCE

Column 1 Reference	STS Reference
3a	4a
3b	4b
3c	4c
3d	4d

Instructional Materials
3ABR53131-SG-203, Air Force Technical Orders
ATCPT 52-4, Air Force Technical Order System
Branch Technical Order File

Audio Visual Aids
Film: TF 5890, Right the First Time

Training Methods
Discussion (1 hr)
Self-Instruction (1 hr)
Performance (6 hrs)

Instructional Environment/Design
Classroom (2 hrs)
Laboratory (6 hrs)

Instructional Guidance
Stress the importance of the proper use of technical orders and manuals. Have each student respond to the written items in the lesson and accomplish ATCPT 52-4, Air Force Technical Order System. Use TO 00-5-1 and TO 00-5-2, AFTO System and Distribution and Storage of AF Technical Order System as reference material.

PLAN OF INSTRUCTION NO. 3ABR53131	DATE 23 September 1975	BLOCK NO. II	PAGE NO. 13

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
4. Cutting Carbon Steel a. Without reference, identify the factors pertaining to oxyacetylene cutting operations with 75% accuracy. b. Given oxyacetylene cutting equipment and carbon steel specimens, cut up and perform cutting operations free of excessive burrs and undercut sections for a total combined distance of no less than 3/4 of the length of the specimen. All shop safety, good housekeeping, and fire prevention measures must be observed.	6	Column 1 Reference STS Reference 4a [illegible] 4b 3a, 3b, 14b Instructional Materials 3ABR53131-SG-204, Cutting Carbon Steel TO 34W4-1-5 Modern Welding (Chapters 3 and 4) Training Equipment Oxyacetylene Welding and Cutting Torch Kit (1) Straight Line Cutting Machine (12) Oxyacetylene Welding Station Complete (1) Power Shears (6) Toolkit (1) Trainer, Oxyacetylene Cutting Applications, 4408 (12) Training Methods Discussion/Demonstration (1 hr) Performance (5 hrs) Instructional Environment/Design Classroom (.5 hr) Laboratory (5.5 hrs) Instructional Guidance Emphasize safety during the use of cutting equipment, and to conserve oxygen and steel plate.

PLAN OF INSTRUCTION NO. 3ABR53131
DATE 23 September 1975
BLOCK NO. II
PAGE NO. 14

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
5. Silver and Lead Soldering a. Without reference, identify the principles and techniques of lead and silver soldering with 75% accuracy. b. Given oxyacetylene welding equipment and metal specimens, set up and solder lap and tee joints with 100% adhesion, free of excessive overlap and oxidation for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.	3	Column 1 Reference — STS Reference 5a — 15a 5b — 3a, 3b, 15b Instructional Materials 3ABR53131-SG-205, Silver and Lead Soldering TO 34W4-1-5 Modern Welding (Chapters 15 and 16) Training Equipment Oxyacetylene Welding Station Complete (1) Power Shears (6) Toolkit (1) Trainer: Hard and Soft Solder Joints, 4406 (12) Training Methods Discussion/Demonstration (1 hr) Performance (2 hrs) Instructional Environment/Design Classroom (.5 hr) Laboratory (2.5 hrs) Instructional Guidance Emphasize shop safety applicable to soldering operations. Stress the requirements for proper joint fit-up and the proper cleaning of material prior to soldering. Have each student respond to the written items in the lesson. Emphasize conservation of high cost silver solder.

MODIFICATIONS

Pages 16 - 17 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
j. Given workbook and AFTO Form 349, complete 12 entries with 75% accuracy. k. Given a list of statemenets, identify the items pertaining to the material deficiency reporting system with 75% accuracy.		out of the maintenance data collection forms. Have each student respond to all written items in the lesson and accomplish ATCPT 52-1, Maintenance Management, Volumes I, II, III, and V. Make home study assignment to read 3ABR53131-SG-208.
8. Brazing Steel and Gray Iron Castings	9 (7/2)	**Column 1 Reference** — **STS Reference** 8a — 16a 8b — 3a, 3b, 16b 8c — 3a, 3b, 16b **Instructional Materials** 3ABR53131-SG-208, Brazing Steel and Gray Iron Castings TO 34W4-1-5 TO 34W4-1-7, Fluxes - Welding, Brazing, and Soldering Modern Welding (Chapter 16) **Audio Visual Aids** Film: Braze Welding Beads **Training Equipment** Oxyacetylene Welding Station Complete (1) Grinders and Buffers (4) Toolkit (1) **Training Methods** Discussion/Demonstration (2 hrs) Performance (5 hrs) **Instructional Environment/Design** Classroom (1.5 hrs) Laboratory (5.5 hrs) **Instructional Guidance** Emphasize the importance of proper joint set-up, flame adjustment, adhesion, and the use of flux. Have each student respond to all written items in the lesson. Make outside assignment to read 3ABR53131-SG-209 and Modern Welding, Chapter 18. Administer appraisal test upon
a. Without reference, identify the mechanical properties produced by brazing ferrous castings and ferrous wrought products with 75% accuracy.	(.5)	
b. Given oxyacetylene welding equipment and gray iron castings, set up and braze butt joints with 100% adhesion, free of excessive oxidation and overlap for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.	(4)	
c. Given oxyacetylene welding equipment and carbon steel specimens, set up and braze butt joints with 100% adhesion, free of excessive oxidation and overlap for a total combined distance of no less than 3/4 the length of the specimen excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.	(2.5)	

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		completion of this assignment. Emphasize conservation of brazing rod and ferrous metal.
9. Fusion Welding Ferrous Castings	8 (6/2)	Column 1 Reference STS Reference 9a 17a 9b 3a, 3b, 17b 9c 3a, 3b, 17c
a. Without reference, identify the mechanical properties and uses of various types of cast iron with 75% accuracy.	(.5)	Instructional Materials 3ABR53131-SG-209, Fusion Welding Ferrous Castings TO 34W4-1-5 TO 34W4-1-7 Modern Welding (Chapter 18)
b. Given metal specimens and grinding equipment, set up and identify cast iron castings by spark testing without error. All shop safety, good housekeeping, and fire prevention measures must be observed.	(.5)	Audio Visual Aids Slides: Ferrous Castings
c. Given oxyacetylene welding equipment and metal specimens, set up and fusion weld butt joints of gray cast iron, with 100% penetration, free of undercut and overlap for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.	(5)	Training Equipment Oxyacetylene Welding Station Complete (1) Grinding Machines (4) Toolkit (1) Training Methods Discussion/Demonstration (1 hr) Performance (5 hrs) Outside Assignment (2 hrs) Instructional Environment/Design Classroom (.5 hr) Laboratory (5.5 hrs) Instructional Guidance Emphasize the use of known specimens in identification of cast iron by the spark testing procedure. Monitor the use of safety equipment during the spark testing operation and the use of flux during cast iron welding. Make outside assignment to read 3ABR53131-SG-210 and Chapter 20, para 1 thru 20, Modern Welding. Administer appraisal test upon completion of this assignment. Emphasize conservation of ferrous castings and filler rod.

PLAN OF INSTRUCTION NO. 3ABR53131	DATE 23 September 1975	BLOCK NO. II	

ATC FORM MAR 73 337A   PREVIOUS EDITIONS OBSOLETE. ☆ U.S. GPO: 1973—779-403/129   (Final Copy – 84% – 8 X 10½)   (Final reduction to include area above this line)

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PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
10. Hard Surfacing a. Without reference, identify the purpose, types, and mechanical properties of hard surfacing materials with 75% accuracy. b. Given oxyacetylene welding equipment and carbon steel specimens, set up and perform hard surfacing operations, free of excessive undercut, overlap, and porosity for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed. c. Given hard surfaced specimens and grinding equipment, set up, grind, and finish hard surface deposit to a smooth, even surface no greater than 3/32 of an inch over the entire area of the specimen. All shop safety, good housekeeping, and fire prevention measures must be observed.	5 (3/2)	Column 1 Reference — STS Reference 10a — 18a 10b — 3a, 3b, 18b 10c — 3a, 3b, 18c Instructional Materials 3ABR53131-SG-210, Hard Surfacing TO 34W4-1-5 Modern Welding (Chapter 20) Training Equipment Oxyacetylene Welding Station Complete (1) Grinders and Buffers (4) Toolkit (1) Training Methods Discussion/Demonstration (1 hr) Performance (2 hrs) Outside Assignment (2 hrs) Instructional Environment/Design Classroom (.5 hr) Laboratory (2.5 hrs) Instructional Guidance Emphasize safety during grinding operations and torch flame adjustment for hard surfacing operations. Make outside assignment to read 3ABR53131-SG-301 and Chapter 6, Modern Welding. Emphasize conservation of hard surfacing rods.
11. Related Training (identified in course chart).	16	
12. Measurement and Critique	2	

PLAN OF INSTRUCTION NO. 3ABR53131	DATE 23 September 1975	BLOCK NO. II	PAGE NO. 20

TWSTI 22 Sept 75 [illegible]

13-5
Lesson Plans

COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction to Oxyacetylene Welding

LESSON TITLE
Shop and Flight Line Safety Practices

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
S-I .5 hr/Perf .5 hr	None	1 hr

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
3	23 Sep 75	4

STS CTS REFERENCE

NUMBER	DATE
STS 531X1	31 May 75

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	1. 3ABR53131-SG-104 2. PT Fundamentals 102C

CRITERION OBJECTIVES AND TEACHING STEPS

a. Given a list pertaining to general housekeeping, identify procedures consistent with safety and fire prevention measures IAW AFR 127-101.

b. Given a list pertaining to shop safety in the performance of required tasks, identify proper safety procedures IAW AFR 127-101.

c. Given illustrations of radiation hazard markings, correctly identify each IAW TO 00-110N-3.

d. Without reference, correctly identify flight line safety hazards and precautions IAW AFR 127-101.

e. Given health and safety equipment, correctly utilize the equipment IAW AFR 127-101.

Teaching steps are listed in Part II.

ATC FORM AUG 72 770

INTRODUCTION TIME: 10 Min.

ATTENTION:

REVIEW: Security classification; identity of classified information; transmission of classified information; voice communications security.

OVERVIEW: Shop and flight line safety; fire prevention; identification of radioactive parts and materials; use of health and safety devices.

MOTIVATION:

BODY TIME:

PRESENTATION:

1. Practice general housekeeping consistent with safety and fire prevention.
   a. Keep machines and floors clear.
   b. Do not leave scrap behind shears.
   c. Use proper cans to discard scrap.
   d. Keep your work area clear.
   e. Eliminate fire hazards.
      (1) No rags or other combustible material in area.
      (2) No books or paper on work table.
   f. Location of fire extinguisher
   g. Phone number, base fire department
   h. No flammable materials in open containers.
   i. Smoking areas

- j. Electrical hazards
    - (1) Equipment grounded
    - (2) No frayed or bare wires
    - (3) Equipment properly fused

2. Shop Safety
    - a. arrange hoses and arc welding leads neatly
    - b. Combustible material containers
        - (1) Flush
        - (2) Steam
        - (3) Electrically grounded
    - c. Hot metal
        - (1) Mark hot
        - (2) Time
        - (3) Quench
    - d. Fire extinguisher in immediate area
    - e. Cylinders
        - (1) Storage
        - (2) Marking
        - (3) Handling
    - f. Keep tools not in use in proper place
    - g. Store metals in rack
    - h. Shop area
        - (1) Clean
        - (2) Well lighted
        - (3) Well ventilated

3. Markings applicable to radioactive parts, material, and areas.

   a. **The primary** purpose **of** the various AFTO Form 9 placards and labels is for warning or identification purposes as described.

   b. All signs display the distinctive magenta insignia against a yellow background with black block type.

   c. TO 00-110N-3, Requisition, Handling, Storing, and Identification of Radioactive and Radioactively Contaminated Material.

4. Observe flight line safety hazards and precautions

   a. Insure that explosive hazards do not exist.

   b. Base fire warden will decide whether welding will be performed when fire hazard exists.

   c. Have fire extinguisher in position prior to welding.

   d. Weld on aircraft only in case of emergency and only by special permission of Chief of Maintenance and Fire Warden.

   e. Weld in designated safe area.

5. Utilize health and safety equipment

   a. Protective clothing and equipment

      (1) Use of guards on machinery

      (2) Clothing suitable for job

      (3) Eye protection

      (4) Select the right tool for the job

      (5) Ventilation

APPLICATION:

1. Student will review and complete 3ABR53131-WS-104.

EVALUATION:

1. Student must answer correctly 75% of all questions.

CONCLUSION TIME: 10 Min.

SUMMARY:

1. Safety and fire prevention
2. Shop safety
3. Identification of radioactive parts and materials
4. Flight line safety
5. Use of health and safety devices

ASSIGNMENT:

1. Review notes
2. Review 3ABR-53131-SG-104, Shop and Flight Line Safety Practices

APPROVAL OFFICE AND DATE TWSTI 23 Sep 75	INSTRUCTOR
COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction to Oxyacetylene Welding
LESSON TITLE Handtools	

LESSON DURATION

CLASSROOM /Laboratory D & D .5 hr/Perf .5 hr	Complementary None	TOTAL 1 hr

POI REFERENCE

PAGE NUMBER 4	PAGE DATE 23 Sep 75	PARAGRAPH 5

STS-CTS REFERENCE

NUMBER STS 531X1	DATE 31 May 75

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	Toolkit	None	1. 3ABR53131-SG-105 2. Chart: Types of Files

CRITERION OBJECTIVES AND TEACHING STEPS

a. Given a toolkit, select and demonstrate the proper use and care of handtools without error.

b. Without reference, identify the proper storage procedures for shop equipment and materials with 75% accuracy.

Teaching steps are listed in Part II.

INTRODUCTION TIME: 10 Min.

ATTENTION:

REVIEW: Safety and fire prevention; shop safety; identification of radioactive parts and material; flight line safety; use of health and safety devices.

OVERVIEW: Select, proper use, and care of handtools. Storage of shop equipment and materials.

MOTIVATION:

BODY TIME:

PRESENTATION:

1. Select use and care of handtools
    - a. Hack saw
        - (1) Types of frames
            - (a) Fixed frames
            - (b) Adjustable frame
        - (2) Blades
            - (a) Teeth per inch
            - (b) Kind of teeth
            - (c) Selection of blade
            - (d) Cutting speed
    - b. Classification of files
        - (1) Name
        - (2) Grade
        - (3) Cut

c. Parts of a file

    (1) Tang

    (2) Heel

    (3) Face

    (4) Length

    (5) Edge

    (6) Tip

d. Correct usage

    (1) Speed

    (2) Pressure

    (3) Cleaning

e. Safety precautions

f. Cold chisels

    (1) Uses

        (a) To cut metal

g. Type

    (1) Cape

    (2) Flat

    (3) Round nose

    (4) Diamond

h. Care

    (1) Keep properly ground

2. Store shop equipment and material

a. Compressed gases

    (1) Oxygen and acetylene cylinders stored separately.

(2) Stored in cool dry area

(3) Cylinder shall be secured in an upright position

(4) Mark cylinders MT when empty

(5) Handle cylinders with care

b. Volatile fluids

(1) Used waste, rags, and other combustible material shall be placed in covered metal cans

(2) Separate containers so marked are used for oil or paint soaked rags.

(3) Covered metal containers are also provided for clean rags.

APPLICATION:

1. Student will select and demonstrate the proper use and care of handtools.

2. Student will review and complete 3ABR53131-WS-105

EVALUATION:

1. Student will select and demonstrate the proper use and care of handtools without error.

2. Student will answer questions with 7590 accuracy.

CONCLUSION TIME: 10 Min.

SUMMARY:

1. Review selection, use, and care of handtools.
2. Storage of shop equipment and materials

ASSIGNMENT:

1. 3ABR53131-SG-106, Operation and Maintenance of Welding Equipment

2. Read TO 34W4-1-5, Welding Theory and Application, Chapter 5, para 5-1 thru 5-15.

3 Modern Welding Handbook, Chapter 2, para 2-1 thru 2-35.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE WSTI 23 Sept 75	INSTRUCTOR
COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction to Oxyacetylene Welding

LESSON TITLE
Operation and Maintenance of Welding Equipment

LESSON DURATION

CLASSROOM/Laboratory D & D 1 hr/Perf 3 hrs	Complementary None	TOTAL 4 hrs

POI REFERENCE

PAGE NUMBER 5	PAGE DATE 23 Sep 75	PARAGRAPH 6

STS/CTS REFERENCE

NUMBER STS 531X1	DATE 31 May 75

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Portable oxyacetylene welding equipment consisting of 1 cart, 1 oxygen cylinder, 1 acetylene cylinder torch outfit, regulators and hoses. 2. Stationary welding equipment consisting (cont on reverse)	Toolkit	None	1. 3ABR53131-SG-106 2. TO 34W4-1-5 3. Modern Welding (Chapter 1 & 2) 4. Film: Adjusting Gas Pressures With Torch Valves open and Lighting Torch (cont on reverse)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Given oxyacetylene welding equipment, assemble and operate oxyacetylene welding equipment IAW TO. All shop safety, good housekeeping, and fire prevention measures must be observed.

b. Given oxyacetylene welding equipment, while observing all shop safety, good housekeeping, and fire prevention measures, test apparatus for gas leaks IAW TO.

c. Given oxyacetylene welding equipment, while observing all shop safety, good housekeeping, and fire prevention measures, adjust torch for proper welding flames IAW TO.

d. Given oxyacetylene welding equipment, while observing all shop safety, good housekeeping, and fire prevention measures, close down and disassemble welding apparatus IAW TO.

e. Given oxyacetylene welding equipment, while observing all shop safety, good housekeeping and fire prevention measures, perform operator maintenance on welding and cutting equipment IAW TO.

ATC FORM AUG 72 770 Teaching steps are listed in Part II. ☆ GPO: 1972 779-398/23

INTRODUCTION

TIME: 10 Min

ATTENTION:

REVIEW: School objectives: Career ladder: Security: Shop and flightline safety: Handtools.

OVERVIEW: Assemble and operate welding equipment: Check for leaks: Adjust for proper flames: Close down and disassemble welding equipment: Operator maintenance on welding and cutting equipment.

MOTIVATION:

BODY

TIME

PRESENTATION:

1. Assemble and operate oxyacetylene welding equipment.
    - a. Welding equipment in general.
        - (1) Stationary or portable stations.
        - (2) Regulators.
            - (a) Single or two stages.
            - (b) Hoses
            - (c) Torches
            - (d) Tips
            - (e) Gases
                - 1 Oxygen
                    - a 99% pure
                - 2 Acetylene
                    - a Compound of carbon and hydrogen.
                    - b Stable at 15 PSI

- c 29.4 PSI becomes self-explosive.
- d Acetone is used to absorb high pressure.
- e Absorbs acetylene 25 times its own volume.
- f Acetone will discharge with acetylene gas unless allowed to stand in an upright position.

(f) Cylinders

- 1 Contents
- 2 Pressures
- 3 Safety features
- 4 Storage of cylinders

b. Assembly of portable unit

(1) Necessary equipment

- (a) Cylinders
- (b) Regulators
- (c) Hoses
- (d) Torch
- (e) Tip

c. Operation of equipment.

(1) Proper procedure for adjusting regulators.

- (a) 5 lbs for acetylene
- (b) 10 lbs for oxygen

(2) Lighting the torch.

(3) Shutting down.

2. Test apparatus for gas leaks
    a. Method used for checking is done with soap and water.
    b. Leaks in the welding hose can be located by immersing the hose in clean water using normal working pressures.
3. Adjust torch for welding flames
    a. Ration of gases.
        (1) Neutral 1-1 ratio.
        (2) Oxidizing 1 1/2 part oxygen
        (3) Carburizing 1 1/2 part acetylene
    b. Lighting the torch
    c. Types of flames and temperatures
        (1) Neutral 5850 degrees
        (2) Oxidizing 6300 degrees
        (3) Carburizing 5700 degrees
4. Close down and disassemble welding apparatus.
    a. Turn acetylene off first
    b. Then oxygen.
    c. Open torch needle valves one at a time and bleed the hoses and regulator
    d. Close the torch needle valves.

- e. Turn the regulator adjusting screws counterclockwise to relieve the pressure on the diagram.
- f. Hang the torch and hose up properly to prevent kinking the hose and damaging the torch.

5. Perform operator maintenance on welding and cutting equipment
   - a. Faulty regulator
     - (1) Leakage of gas between seat and nozzle.
       - (a) Gradual increase in working pressure
       - (b) Defective bourdon tube.
   - b. Maintenance
     - (1) Test regulator valve seat
     - (2) Test for leaky connections
     - (3) Correcting leaking valve seat
     - (4) Correcting leaking connections
     - (5) Repairing leaking diaphrams
     - (6) Repairing leaking torch valve
     - (7) Cleaning torch tips
     - (8) Cleaning clogged tubes
     - (9) Repair of hose

c. Practice shop safety in performance of required tasks.

- (1) Use goggles when looking directly at flame.
- (2) Wear protective clothing.
- (3) Get tools needed from kit then close box.
- (4) Never leave torch burning while hung on hanger provided on bench.
- (5) Always turn off the acetylene torch valve first.
- (6) Handling materials and equipment
  - (a) Lifting
    - 1 To avoid strains, sprains, and hernias due to improper lifting, levers, jacks and other moving equipment shall be used to move heavy equipment.
    - 2 If lifting must be done by hand, obtain help to avoid strains.
    - 3 Stnad close to the load and lift with the legs.
  - (b) Handling
    - 1 Finger rings shall not be worn when handling or storing material.
    - 2 Gloves shall be worn when handling sheet stock.

APPLICATION

Each student will perform the following.

1. Assemble and operate oxyacetylene welding rig.
2. Test apparatus for gas leaks
3. Adjust torch for proper flames.
4. Close down and disassemble welding apparatus
5. Perform operator maintenance on welding equipment

EVALUATION:

1. Student progress will be checked during set up of equipment for proper procedure.
2. Assistance will be given when necessary.

CONCLUSION: TIME: 10 Min

Summary:

1. Assembling and operating welding equipment.
2. Test apparatus for leaks
3. Adjust torch for proper welding flames.
4. Close down and disassemble welding equipment.
5. Perform operator maintenance on welding equipment.

ASSIGNMENT:

1. Review notes
2. Read 3ABR53230-SG-107, Beads and Lap Joints of Carbon Steel
3. Answer questions in 3ABR53230-WS-107.
4. TO 34W4-1-5 Welding Theory and application para 6-1 thru 6-11.
5. Modern welding para 1-1 thru 1-34.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 22 Sep 75	INSTRUCTOR
COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction to Oxyacetylene Welding

LESSON TITLE
Beads and Lap Joints of Carbon Steel

LESSON DURATION

CLASSROOM /Laboratory D & D 2 hrs/Perf 10 hrs	Complementary None	TOTAL 12 hrs

POI REFERENCE

PAGE NUMBER 6	PAGE DATE 23 Sep 75	PARAGRAPH 7

STS/CTS REFERENCE

NUMBER STS 531X1	DATE 31 May 75

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Stationary Oxy-acetylene Welding Equipment Complete 2. Power Shears 3. Trainer: 311	Toolkit	None	1. 3ABR53131-SG-107 2. 3ABR53131-HO-100 3. TO 34W4-1-5 4. Modern Welding (Chapter 1) 5. Film: Weld Beads Using Filler Rods Film: Flame Effect on Molten Pool (cont on reverse)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Given a list of types of carbon steel, identify the properties and uses of each with 75% accuracy.

b. Given power equipment, operate equipment, and cut metal to study guide specifications. All shop safety, good housekeeping, and fire prevention measures must be observed.

c. Given oxyacetylene welding equipment and carbon steel specimens, set up and weld beads on sheet steel, free of excessive penetration, oxidation, overlap, and undercut for a total combined distance of no less than 3/4 the length of the specimen, excluding the first ½ inch start and the last ½ inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.

d. Given oxyacetylene welding equipment and carbon steel sheet specimens, set up and weld lap joints in the flat position, free of excessive penetration, undercut, oxidation, and overlap for a total combined distance of no less than 3/4 the length of the specimen excluding the first ½ inch start and the last ½ inch. All shop safety, good housekeeping and fire prevention measures must be observed.

Teaching steps are listed in Part II.

ATC FORM AUG 72 770

GRAPHIC AIDS AND UNCLASSIFIED MATERIAL (cont)

Film: Lines of Fusion Beads Without Rods

Film: Fillet Welds

37

INTRODUCTION TIME: 10 Min.

ATTENTION:

REVIEW: Assembling and operating welding equipment; test for gas leaks proper welding flames; close down and disassemble welding equipment; operator maintenance on welding equipment.

OVERVIEW: Characteristics and uses of carbon steel; setup and weld beads; welding lap joints in the flat position; operating power equipment; preparing metal specimens.

MOTIVATION:

BODY TIME:

PRESENTATION:

1. Characteristics and uses of carbon steel
   a. Three types of carbon steel
      (1) Low carbon .008-1030
      (2) Med carbon 1031-1045
      (3) High carbon 1046-2%
   b. Characteristics of carbon steel
      (1) Weldability depends upon carbon content
      (2) As carbon content increases weldability decreases.
      (3) Carbon is a hardening agent used in steel to make it more stronger
   c. Uses
      (1) Weapons syters
      (2) Transportation

- (3) Home
- (4) Industry

d. Properties of metal
- (1) Heat conductivity
- (2) Expansion
- (3) Contraction

e. Controlling expansion and contraction
- (1) Fixtures
- (2) Stress relieving
- (3) Amount of heat
- (4) Welding sequence

f. Strength of welded joints
- (1) Weld metal deposit
- (2) Type of joint
- (3) Size of the weld
- (4) Location of the weld
- (5) Operator skill

g. Terminology
- (1) "T" thickness of the base metal
- (2) Fusion zone
- (3) Root
- (4) Throat
- (5) Weld reinforcement
- (6) Face
- (7) Toes

(8) Leg (lap joint)

(9) Penetration

h. Welding methods

(1) Forehand

(2) Backhand

i. Filler rod

(1) Composition

(2) Size

(3) Purpose

j. Welding tip size selection

(1) Thickness of the base metal

(2) Heat conductivity

2. Set up and weld beads

a. Joint preparation

(1) Remove scale, rust, oxides from metal, to keep impurities out of the weld.

(2) Burrs must be removed from edges

(a) Grinders

(b) Files

(c) Position plate

b. Beads without filler rod

(1) Neutral flame

(2) Molten pool (2480-2750° F)

(3) Slight circular motion in direction of travel

(4) Bead width

c. Beads with filler rod

  (1) Neutral flame

  (2) Molten pool

  (3) Add filler rod to leading edge of molten pool

  (4) Move torch from side to side

  (5) Forehand method

    (a) For metal up to ¼" thick

    (b) Torch angle 60° in the direction of travel

    (c) Filler rod 45°

d. Bead specifications

  (1) 1/16" - 3/32" thick metal

  (2) Bead width 2-4 T

  (3) Penetration 25% - 50%

  (4) Reinforcement 1T max.

3. Set up and weld lap joints in the flat position

a. Types of lap joints

  (1) Single fillet

    (a) Welded on one side only.

    (b) Does not develop full strength but is stronger than a butt weld on some applications.

    (c) When tubing or framer overlap or telescoped together the lap joint is preferable to the butt joint.

  (2) Double fillet

    (a) Welded on both sides

    (b) Suitable for more severe load conditions then single fillet lap joint.

    (c) Does develop full strength of the base metal.

  (3) Joggled lap joint

    (a) Used when metal must be kept on the same plane.

    (b) Difficult to prepare.

    (c) Produces a greater strength than the single fillet lap joint.

b. Welding specifications for lap joints

  (1) Fusion zone

    (a) The area of weld metal which has penetrated beyond the original surface of the base metal.

  (2) Legs - Upper, equal to base metal (1T)
  Lower, 1½ T

  (3) Root

    (a) Portion of the weld metal deposited at the bottom of the joint..

  (4) Toes, good fusion.

    (a) Located at the edges of the weld face.

    (b) Without undercut or overlap.

  (5) Face slightly convexed

    (a) Outer surface of weld face

  (6) Penetration

        - (a) 30 to 50% of thickness.
    - (7) Throat
        - (a) 1T
        - (b) The distance through the center of the weld from the root to the face.
    - (8) On metals of different thickness, base specifications on lighter metals
- c. Procedures for lap joints 1/8" or less
    - (1) Clean and deburr
    - (2) Overlap plates 4-6 T.
    - (3) Tack at 1½" intervals
    - (4) Check fit up
    - (5) Forehand method of welding
        - (a) Torch angle 60 degrees in direction of welding.
        - (b) Filler rod 45 degrees
    - (6) Pre-heat metal plates.
        - (a) More heat on bottom plate.
    - (7) Add filler rod in upper edge of molten pool.
    - (8) Keep molten pool centered between both sheets of metal.
    - (9) Determine speed of travel by size of molten pool.
- d. Welding faults
    - (1) Excessively concaved bead
        - (a) Too much heat
        - (b) Not enough filler rod.

(2) Excessively convexed bead

(a) Not enough heat

(b) Too much filler rod

(3) Undercut

(a) Usually at toes of welds

(b) Wrong torch angle.

(c) Overheating

(4) Overlap

(a) Usually at toes of welds

(b) Underheating metal

(c) Improper addition of filler rod

4. Operate power equipment

a. One operator at a time.

b. Remove all jewelry

c. Material will be placed under hold down.

5. Practices safety in operation power equipment and welding equipment

a. No horse playing or running allowed

b. Secure proper guard on grinders.

c. Keep machines and floor clean.

d. Check for electrical hazards.

e. Secure oxyacetylene rig.

6. Utilize health and safety equipment

a. Protective clothing and equipment

(1) Use of guards on machinery

(2) Clothing suitable for job

(3) Eye protection

APPLICATION

1. Given materials and equipment for stringer beads and lap joints, the student will:
   a. Prepare joints for welding
   b. Weld joints to specifications
2. Students will observe all safety precautions during accomplishment of project.

EVALUATION:

1. Students projects will be checked during layout, and welding for proper procedures.
2. Assistance will be given when necessary.

END OF DAY SUMMARY

SUMMARY (Day 2 - 2 Hrs)

1. Characteristics and uses of carbon steel
2. Welding procedures
3. Welding faults
4. Specifications on welding beads on plates and lap joints
5. Operate power equipment, prepare metal specimens

ASSIGNMENT:

1. Review notes of classroom discussion.
2. Review 3ABR53230-SG-107 and 3ABR53230-WS-107.

3. Review TO 34W4-1-5 para 6-1 thru 6-11

4. Review Modern Welding Handbook, para 1-1 thru 1-23

INTRODUCTION TO NEW DAYS INSTRUCTION

(Cont'd Day 3, 6 hrs)

1. Remotivation:

2. Review:

   a. Characteristics and uses of carbon steel

   b. Set up and weld beads

   c. Set up and weld beads in the flat position

   d. Operate power equipment and prepare metal specimens

3. Check home work assignment.

APPLICATION: (Cont'd)

Refer to objectives 2,3,4

1. Given materials and equipment for stringer beads and lap joints the student will:

   a. prepare joints for welding.

   b. weld joints to specifications.

2. Students will observe all safety precautions during operation of power equipment and preparation of metal specimens.

EVALUATION:

1. Student project will be checked for proper welding procedure and preparation.

2. Assistance will be given when necessary.

END OF DAY SUMMARY

SUMMARY (Day 3, 6 hrs)

1. Welding beads
2. Set up and welding of lap joints in the flat position
3. Operating power equipment and preparing metal specimens

ASSIGNMENT:

1. Review notes taken in classroom discussion
2. Review 3ABR53230-SG-107 and work sheet.
3. Review TO 34W4-1-5 para 6-1 thru 6-11
4. Review Modern Welding Handbook para 1-1 thru 1-23

INTRODUCTION TO NEW DAYS INSTRUCTION

(Cont'd Day 4, 4 hrs)

1. Remotivation
2. Review
    a. Welding beads
    b. Set up and weld lap joints in the flat position
    c. Operation of power equipment, metal preparation.
3. Check home work assignment

APPLICATION: (Cont'd)

Refer to Objectives 2, 3, 4

1. Given materials and equipment for stringer beads and lap joints, the student will:
    a. prepare joints for welding.
    b. weld joints to specifications.

Students will observe all safety precautions during operation of power equipment and preparation of metal specimens.

EVALUATION:

1. Students projects will be checked during layout and welding for proper procedures.

2. Assistance will be given when necessary.

CONCLUSION TIME: 10 Min

SUMMARY:

1. Characteristics and uses of carbon steel
2. Set up and weld beads
3. Set up and weld lap joints in the flat position
4. Operate power equipment and prepare metal specimens

ASSIGNMENT:

1. Read 3ABR53230-SG-108, Butt Joints of Carbon Steel
2. Answer questions in 3ABR53230-WS-108
3. Read TO 34W4-1-5, Welding Theory and Application para 6-7b.
4. Read Modern Welding Handbook, para 1-20

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 22 Sept 75 Richard	INSTRUCTOR
COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction to Oxyacetylene Welding

LESSON TITLE
Butt Joints of Carbon Steel

LESSON DURATION

CLASSROOM /Laboratory	Complementary		TOTAL
D & D 2 hrs/Perf. 10 hrs	None		12 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
7	23 Sep 75	8

STS/CTS REFERENCE

NUMBER	DATE
STS 531X1	31 May 75

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Stationary Oxy-acetylene Welding Equipment, Complete 2. Trainer: 3217 3. Power Shears	Toolkit	None	1. 3ABR53131-SG-108 2. TO 34W4-1-5 3. Modern Welding (Chapter 1) 4. Slides - Butt 5. Film: The Square Butt Joint

CRITERION OBJECTIVES AND TEACHING STEPS

a. Given oxyacetylene welding equipment and carbon steel specimens, set and weld butt joints in the flat position, with 100% penetration, free of undercut, overlap and excessive oxidation for a total combined distance of no less than 3/4 the length of the specimen excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.

Teaching steps are listed in Part II.

INTRODUCTION

TIME: 10 Min.

ATTENTION:

REVIEW: Characteristics and uses of carbon steel; metal preparation; welding beads; setup and weld lap joints in the flat position; welding terminology; operating power equipment; weld bead specifications.

OVERVIEW: Preparation and set up of metal for a butt joint; types of butt joints; welding technique; weld bead specifications.

MOTIVATION:

BODY

TIME:

PRESENTATION:

1. Joint preparation
    - a. Remove all scale, rust, and oxides from the metal surface to keep impurities out of the weld.
    - b. Burrs must be removed from edges
        - (1) Grinder
        - (2) File
    - c. Thickness of metal
        - (1) 1/8" or less no beveling required
        - (2) Over 1/8" bevel one or both sides
        - (3) Single V
        - (4) Double V
        - (5) Single U
        - (6) Double U

2. Set up and weld butt joints in the flat position.

   a. Edges on the same plane

   b. Support plates with edges between fire bricks

   c. Rigid butt joints

      (1) Space 1 T

      (2) Tack at 1½" intervals

         (a) Keep tacks small

         (b) Check alignment after tacking

         (c) 100% penetration

      (3) Use horse shoe method

         (a) Repeat process as filler rod is added

   d. Open butt joint

      (1) One tack is required to hold sheets of metal on the same plane.

      (2) Space front edges 1T and back edges 1T plus ¼" per foot of seam length

   e. Welding procedure

      (1) Clean metal

      (2) Neutral flame

      (3) Use forehand method

      (4) Torch angle 60 degree

      (5) Filler rod 45 degree

      (6) Inner cone 1/16" above molten pool

(7) Dip filler rod in center of molten pool

f. Weld bead specifications

(1) Height of reinforcement 75% of T.

(2) Width of reinforcement 2-4T

(3) Penetration 100%

(4) No undercut

(5) No overlap

(6) Even contour

(7) Taper gradually into base metal at the toes of the weld

3. Operate power equipment

a. One operator at atime.

b. Remove all jewelry

c. Material will be placed under hold down clamp

4. Practice shop safety in performance of required task

a. No horse playing or running allowed

b. Use guard on machinery

c. Proper clothing for protection

d. Wear proper eye protection

5. Practice general housekeeping consistent with safety and fire protection

a. Keep machine and floor clean.

b. Do not leave scrap on shears

c. Keep work area clean

d. Eliminate fire hazards

(1) No rags or other combustible material in area.

(2) Use proper container to discard scrap in.

APPLICATION:

1. Given materials and equipment for welding butt joints the student will
   - a. prepare joints for welding.
   - b. weld joints to specifications.
2. Students will observe all safety precautions during accomplishment of project.

EVALUATION:

1. Students projects will be checked during layout and welding for proper procedures.
2. Assistance will be given when necessary.

END OF DAY SUMMARY

SUMMARY: (Day 4, 2 hrs)

1. Joint preparation
2. Set up
3. Welding procedures
4. Bead specifications

ASSIGNMENT:

1. Review notes taken during classroom hours.
2. Review 3ABR53230-SG-108 and work sheet.
3. Review TO 34W4-1-5
4. Review Modern Welding Handbook

INTRODUCTION TO NEW DAYS INSTRUCTION

(Cont'd Day 5, 6 Hrs)

1. Remotivation
2. Review
   a. Joint preparation
   b. Set up
   c. Welding procedures
   d. Bead specifications
3. Check home work assignment.

APPLICATION:

Refer to Objective 1

1. Student will be given material and equipment for welding butt joint. Student will perform the following:
   a. Prepare joints for welding.
   b. Weld joints to specifications.
2. Students will observe all safety precautions during accomplishment of project.

EVALUATION:

1. Student project will be checked for proper welding procedure and preparation.
2. Assistance will be given when necessary.

END OF DAY SUMMARY

SUMMARY (Day 5, 6 Hrs)

1. Joint preparation
2. Set up
3. Welding procedures
4. Bead specifications

ASSIGNMENT:

1. Review notes taken in classroom
2. Read 3ABR53230-SG-108 and work sheet.
3. Review TO 34W4-1-5
4. Review Modern Welding Handbook.

INTRODUCTION TO NEW DAYS INSTRUCTION

(Cont'd Day 6, 4 hrs)

1. Remotivation
2. Review
    a. Joint preparation
    b. Set up
    c. Welding procedures
    d. Bead specifications
3. Check home work assignment

APPLICATION:

Refer to Objective 1

1. Given material and equipment student will perform the following:
    a. Prepare joint for welding
    b. Weld joint to specifications.

Students will observe all safety precautions during the accomplishment of project.

EVALUATION:

1. Student project will be checked for proper welding procedure and preparation.
2. Assistance will be given when necessary.

CONCLUSION TIME: 10 Min.

SUMMARY:

1. Joint preparation
2. Bead specifications
3. Set up and weld butt joints in the flat position.

ASSIGNMENT:

1. Read 3ABR53230-SG-109, Tee Joints of Carbon Steel
2. Answer questions in 3ABR53230-WS-109.
3. Read TO 34W4-1-5, para 3-18.
4. Read Modern Welding Handbook, para 1-23.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE WSTI 22 Sept 75	INSTRUCTOR
COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction to Oxyacetylene Welding

LESSON TITLE
Tee Joints of Carbon Steel

LESSON DURATION

CLASSROOM/Laboratory D & D 2 hrs/Perf 10 hrs	Complementary None	TOTAL 12 hrs

POI REFERENCE

PAGE NUMBER 8	PAGE DATE 23 Sep 75	PARAGRAPH 9

STS CTS REFERENCE

NUMBER STS 531X1	DATE 31 May 75

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Stationary Oxyacetylene Welding Equipment, Complete 2. Trainer: 3217 3. Power Shears	Toolkit	None	1. 3ABR53131-SG-109 2. TO 34W4-1-5 3. Modern Welding (Chapter 1)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Given oxyacetylene welding equipment and carbon steel specimens, set up and weld tee joints in the flat position, free of undercut, overlap, excessive penetration, and oxidation for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping and fire prevention measures must be observed.

Teaching steps are listed in Part II.

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INTRODUCTION TIME: 10 Min.

ATTENTION:

REVIEW: Procedures and techniques for welding butt joints in the flat position.

OVERVIEW: Procedures and techniques for welding tee joints in the flat position.

A

MOTIVATION:

BODY TIME:

PRESENTATION:

1. Joint preparation

   a. Remove scale, rust, and oxides from the metal surface to keep impurities out of the weld.

   b. Burns must be removed from edges.

      (1) Grinder

      (2) File

   c. Thickness of metal

      (1) 1/8" or less no beveling required

      (2) Over 1/8"-1/2" bevel single V, 45°

      (3) Over 1/2" bevel double V, 45° welded on both sides

      (4) Over 1/2" single U bevel welded on one side only

2. Set up and weld tee joint in the flat position

   a. Space vertical sheet 1/32"-1/16" above horizontal sheet

        (1) Permits easier fusion
        (2) No excessive heating
    b. Tack weld at 1½" intervals when welding on both sides
        (1) Tack alternately from one side to the other
        (2) Keep tacks small
        (3) Check alignment
        (4) Check proper spacing
        (5) Preheat bottom plate
        (6) Most of heat directed on bottom sheet
        (7) Check angle of torch
        (8) Add filler rod on upper edge of molten pool
        (9) Neutral flame
    c. Weld bead specifications
        (1) Upper leg 1½" T
        (2) Lower leg 1½" T
        (3) 30-50% penetration
        (4) Flat to convex face
3. Operate power equipment
    a. One operator at a time
    b. Remove all jewelry.
    c. Material will be placed under hold down clamp (shear)

Practice shop safety in performance of required task.

   a. No horse playing or running allowed.

   b. Use guard on machinery.

   c. Proper clothing for protection.

   d. Wear proper eye protection

5. Practices general housekeeping consistent with safety and fire prevention.

   a. Keep machine and floor clean.

   b. Do not leave scrap behind shears or other equipment.

   c. Keep work area clean.

   d. Eliminate fire hazard.

   e. No rags or other combustible material in area.

   f. Use only proper can to discard scrap.

APPLICATION:

Refer to Objective 1.

1. Given materials and equipment for welding tee joints, the students will

   a. prepare joints for welding.

   b. weld joints to specifications.

2. Students will observe all safety precautions during accomplishment of project.

EVALUATION:

1. Students projects will be checked during layout and welding for proper procedures.

2. Assistance will be given when necessary.

END OF DAY SUMMARY

SUMMARY: (Day 6, 2 hrs)

1. Joint preparation
2. Set up and weld tee joint.
3. Bead specifications

ASSIGNMENT:

1. Review notes taken in classroom during discussion.
2. Review 3ABR53230-SG-109 and worksheet
3. Review TO 34W4-1-5
4. Review Modern Welding Handbook

INTRODUCTION TO NEW DAYS INSTRUCTION

(Cont'd Day 7, 6 hrs)

1. Remotivation
2. Review
   a. Joint preparation
   b. Set up and weld tee joint
   c. Weld bead specifications
3. Check home work assignment

APPLICATION:

Refer to objective 1

1. Given material and equipment the student will

   a. Prepare joints for welding.

   b. Weld tee joints to specifications.

2. Students will observe all safety precautions during accomplishment of project.

EVALUATION:

1. Student project will be checked during preparation and for proper welding procedures.

2. Assistance will be given when necessary.

END OF DAY SUMMARY

SUMMARY: (Day 7, 6 hrs)

1. Joint preparation
2. Set up and weld tee joint
3. Bead specifications

ASSIGNMENT:

1. Review notes taken in classroom discussion.
2. Review 3ABR53230-SG-105 and work sheet.
3. Review TO 34W4-1-5
4. Review Modern Welding Handbook

INTRODUCTION TO NEW DAYS INSTRUCTION

(Cont'd Day 8, 4 hrs)

1. Remotivation
2. Review
   - a. Joint preparation
   - b. Set up and weld tee joint
   - c. Weld bead specifications
3. Check homework assignment

APPLICATION:

Refer to objective 1.

1. Given material and equipment the student will
   - a. prepare joints for welding.
   - b. weld tee joints to specifications.
2. Students will observe all safety precautions during accomplishment of project.

EVALUATION:

1. Student project will be checked during preparation and for proper welding procedures.
2. Assistance will be given when necessary.

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CONCLUSION TIME: 10 Min.

SUMMARY:

1. Joint preparation

2. Set up and weld tee joint in the flat position

3. Operation of power equipment.

ASSIGNMENT:

1. Read 3ABR53230-SG-110, Position Welding.

2. Answer questions in WS-110.

3. Read TO 34W5-1-5, Welding Theory and Application para 7-7 thru 7-8.

4. Read Modern Welding Handbook, para 1-25 thru 1-26.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE STI 22 Sept 75	INSTRUCTOR
COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction to Oxyacetylene Welding

LESSON TITLE
Position Welding

LESSON DURATION

CLASSROOM/Laboratory D & D 2 hrs/Perf 10 hrs	Complementary None	TOTAL 12 hrs

POI REFERENCE

PAGE NUMBER 9	PAGE DATE 23 Sep 75	PARAGRAPH 10

STS-CTS REFERENCE

NUMBER STS 531X1	DATE 31 May 75

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Stationary Oxyacetylene Welding Equipment, Complete 2. Trainer: 3217 3. Power Shears	Toolkit	None	1. 3ABR53131-SG-110 2. TO 34W4-1-5 3. Modern Welding (Chapter 1)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Given oxyacetylene welding equipment and carbon steel specimens, set up and make fillet welds in the horizontal position, free of undercut, overlap, and excessive oxidation, for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping and fire prevention measures must be observed.

b. Given oxyacetylene welding equipment and carbon steel specimens, set up and make fillet welds in the vertical position, free of undercut, overlap, and excessive oxidation for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish.

Teaching steps are listed in Part II.

INTRODUCTION TIME: 10 Min.

ATTENTION:

REVIEW: Procedures and techniques for welding tee joints in the flat position.

OVERVIEW: Procedures and techniques for making fillet welds in the horizontal and vertical position.

MOTIVATION:

BODY TIME:

PRESENTATION:

1. Welding positions
   - a. Horizontal
     - (1) Parts in vertical position and inclined more than 45°.
     - (2) Seam running horizontally.
   - b. Vertical
     - (1) Parts inclined more than 45°.
     - (2) Seam running vertically.
2. Factors restraining force of gravity.
   - a. Cohesion of the molten pool
     - (1) Parent metal and add filler rod being thoroughly locked together
     - (2) A factor affecting cohesion is the amount of heat applied.
     - (3) More heat increases fluidity.

        (4) Resulting in greater tendency of metal to run or fall.

        (5) Most important factor in position welding.

    b. Support provided by the base metal and solidified filler metal.

        (1) Solidified weld metal, as the bead is forming, acts as a shelf to keep molten pool from running or sagging.

    c. Flame pressure

        (1) Keeps pool from running or sagging.

        (2) Pushes pool forward.

    d. Mainpulation of filler rod

        (1) Chilling affect

    e. Surface tension

3. Set up and make fillet welds in the horizontal position

    a. Clean and deburr metal

    b. Lay metal flat

    c. Overlap pieces ½"

    d. Tack weld every 1½"

    e. Incline joints at 45° angle, or more

        (1) Seam running horizontal

    f. Welding in the horizontal position

        (1) Torch angle 45 degrees

        (2) Direct flame slightly upward

        (3) Move tip from side to side to deposit metal uniformly.

        (4) Add filler rod to upper edge of molten pool.

4. Set up and make fillet welds in the vertical position
    a. Prepare metal
    b. Set up and tack weld in the flat position
    c. Incline joints at 45° angle or more
        (1) Seam running vertically
    d. Welding in the vertical position
        (1) Flame pointed upward at 45 degree angle.
        (2) Pressure of gases from tip helps support molten metal.
        (3) Remove flame momentarily if metal becomes overheated.
        (4) Solidified metal below acts as a shelf and provides additional support.
5. Operate power equipment
    a. One operator at a time.
    b. Remove all jewelry.
    c. Material will be placed under hold down clamp. (Shear)
6. Practices shop safety in performance of required task.
    a. No horse playing or running allowed.
    b. Use guard on machinery.
    c. Proper clothing for protection.
    d. Wear proper eye protection.

7. Practices general housekeeping consistent with safety and fire prevention.
    a. Keep machine and floor clean.
    b. Do not leave scrap behind shear or other equipment.
    c. Keep work area clean.
    d. Eliminate fire hazards.
        (1) No rags or other combustible material in area.
        (2) Use only proper can to discard scrap.
8. Utilize health and safety equipment
    a. Protective clothing and equipment
        (1) Use of guards on machinery.
        (2) Clothing suitable for job.
        (3) Eye protection

APPLICATION:

Refer to objectives 1 and 2

1. Given materials and equipment for making fillet welds, the student will
    a. prepare joints for welding.
    b. weld joints to specifications.
2. Student will observe all safety precautions during accomplishment of project.

EVALUATION:

1. Student project will be checked on during preparation of joint and proper welding procedures.
2. Assistance will be given when necessary.

END OF DAY SUMMARY

SUMMARY: (Day 8, 2 hrs)

1. Joint preparation
2. Welding procedures
3. Welding specifications

ASSIGNMENT:

1. Review notes
2. Review 3ABR53230-SG-110
3. Answer questions in 3ABR53230-WS-110
4. Read TO 34W4-1-5, para 6-8
5. Read Modern Welding Handbook, para 1-25 thru 1-26

INTRODUCTION TO NEW DAYS INSTRUCTION

(Cont'd Day 9, 6 hrs)

1. Remotivation
2. Review
    a. Joint preparation
    b. Welding procedures
    c. Welding specifications
    d. Check homework assignment

APPLICATION:

Refer to objectives 1 and 2

1. Given materials and equipment for making fillet welds the student will
    a. prepare joints.
    b. weld joints to specifications.
2. Student will observe all safety precautions during accomplishment of project.

EVALUATION:

1. Student projects will be checked during preparation of joint and proper welding procedure.
2. Assistance will be given when necessary.

END OF DAY SUMMARY

SUMMARY: (Day 9, 6 hrs)

1. Joint preparation
2. Welding procedures
3. Welding specifications

ASSIGNMENT:

1. Review notes
2. Review 3ABR53230-SG-110
3. Complete 3ABR53230-WS-110
4. Review TO 34W4-1-5
5. Review Modern Welding Handbook

INTRODUCTION TO NEW DAYS INSTRUCTION

(Cont'd Day 10, 4 hours)

1. Remotivation
2. Review
    a. Joint preparation
    b. Welding procedures
    c. Welding specifications
    d. Check homework assignment

APPLICATION:

Refer to objectives 1 and 2

1. Given materials and equipment, the student will
    a. prepare joints.
    b. set up and weld joints to specifications
2. Students will observe all safety precautions during accomplishment of project.

EVALUATION:

1. Student project will be checked on during preparation of joint and proper welding procedures.
2. Assistance will be given when necessary.

CONCLUSION TIME: 10 Min.

SUMMARY:

1. Welding positions
2. Factors restraining the force of gravity
3. Set up and welding procedures
4. Operation of power equipment
5. Shop safety
6. Health and safety equipment

ASSIGNMENT:

1. Read 3ABR53230-SG-201, Mechanical Drawing and Blueprint Reading
2. Answer questions in 3ABR53230-WS-201, Mechanical Drawing and Blueprint Reading.
3. Read TO 34W4-1-5, Welding Theory and Application, para 11-1 thru 11-3.
4. Read Modern Welding Handbook, para 28-25.

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 26 Sept 75	INSTRUCTOR
COURSE NUMBER BR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER II	BLOCK TITLE Oxyacetylene Welding, Cutting, Soldering, Brazing and Hard Surfacing

LESSON TITLE

Mechanical Drawing and Blueprint Reading

LESSON DURATION

CLASSROOM /Laboratory	Complementary	TOTAL
D & D 2 hrs/Perf 6 hrs	None	8 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
11	23 Sep 1975	1

STS/CTS REFERENCE

NUMBER	DATE
STS 531X1	31 May 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Drawing Equipment	None	None	1. 3ABR53131-SG-201 2. Blueprint - TA-36 3. Charts, Mechanical Drawing

CRITERION OBJECTIVES AND TEACHING STEPS

a. Given shop drawings, diagrams, and blueprints, identify and interpret the dimensions for each with 75% accuracy.

b. Given drawing material and 3ABR53131-SG-201, make shop drawings and sketches of welded assemblies. Drawings must be within 1/32 inch of study guide dimensions.

Teaching steps are listed in Part II.

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INTRODUCTION TIME: 10 Min.

1. ATTENTION: Talk about lessons in Block II, Drawing and Blue Prints, Maintenance Management, to Systems, etc. Talk about doing assignments, notes, participation.

2. REVIEW: Security, Safety practices, operation and maintenance of oxyacetylene welding equipment, types of flames.

3. OVERVIEW: Upon completion of this lesson you will be able to explain the purpose and use of blue prints the various views and information found on a print and also lay out tubular assembly drawing.

4. MOTIVATION: Need for welder to know how to read and interpret blue print for fabrication of anything (Tool box rack, tirerack, aircraft, engine part patches).

BODY TIME: 7 hrs 40 min.

PRESENTATION

1. Purpose of a drawing
    a. Shape of an object
    b. Size of an object
    c. Details of an object
2. Interpret shop drawing, diagrams and blueprints
    a. Purpose of blueprints
        (1) Show how the job is to be done
        (2) One man's plan can be transferred to others
    b. Use
        (1) Show various views, dimensions and details.
    c. Construction of blueprints
    d. Interpreting sectional views

- (1) Sectional views make it possible to look inside a part
- (2) The type of section is determined by the amount of exterior removed.

e. Other information found on blueprints

- (1) Title block
- (2) Change block
- (3) General notes
- (4) Local notes

3. Identification and use of drawing equipment

a. Drawing board

- (1) Use and care
- (2) Construction

b. Drawing paper

- (1) Color
- (2) Position on board
- (3) Fastening on board

c. Drawing pencils

- (1) Types and numbering
- (2) Sharpening
- (3) Use in line drawing

d. T-Square

- (1) Construction
- (2) Position on board
- (3) Use of blade

e. Triangles

- (1) 30° 60° Triangle-90°
- (2) 45° Triangle-90°
- (3) For use with T-square for drawing vertical and sloping lines

f. Protractor

- (1) Purpose
- (2) Proper use

g. Scales

- (1) Shapes
- (2) Types
- (3) Graduations

h. Compass

- (1) Purpose
- (2) Construction

4. Drawing to scale
    a. Ratio of drawing to object
    b. Detail drawings usually to size
5. Geometric Principles and Construction
    a. Circle
        - (1) A line drawn equidistant from the center
        - (2) Diameter
        - (3) Radius
        - (4) Circumference
        - (5) Arc
    b. Perpendicular lines
    c. Parallel lines

d. Angles

e. Geometric principles are used to accomplish various drawing problems rapidly and accurately.

INTERIM SUMMARY

6. Standard drawing lines

   a. Object line

      (1) Heavy solid line

      (2) Represent outline of object

   b. Hidden lines

      (1) Short dashes, medium weight

      (2) Distinguish surfaces that cannot be seen

   c. Center lines

      (1) Alternating long and short dashes medium weight

      (2) Used to locate the exact centers of holes, arcs, radii and cylinders

   d. Extension line

      (1) Light weight, unbroken line

      (2) Showing limits of dimensions

   e. Dimensions line

      (1) Light weight with arrow heads on ends

   f. Projection line

      (1) Extremely light

      (2) Project different views

7. Types of drawing

   a. Orthographic

- b. Perspective
- c. Isometric
- d. Oblique
- e. Orthographic most used

8. Shop drawings and sketches of welded assemblies
    - a. Front, top and side views
        - (1) Front view shows length and height
        - (2) Top view shows length and width
        - (3) Side view shows height and width
    - b. Principles of dimensioning
        - (1) Detail
        - (2) Position
        - (3) Overall
    - c. Letters and figures
        - (1) Style of letters
        - (2) Placement of figures
    - d. Limits
    - e. Tolerance

9. Sectionalized drawings
    - a. Full section
    - b. Half section
    - c. Broken-out or partial section

10. Crosshatched sections
    - a. Purpose

b. Use

c. Types

11. Welding Symbols

a. Purpose

b. Basic types

c. Location of weld symbol on welding symbol reference line

INTERIM SUMMARY

APPLICATION:

1. Students will interpret dimensions and views using mobile filing cabinet drawing.

2. Each student will construct a shop drawing of the station joint in SG 201 Figure 19.

EVALUATION:

1. Using shop drawing student will interpret the following with 75% accuracy.

a. Locate and list the overall dimension on the side view.

Ans. 16"

b. What type of dimension is the 22 5/8" on the front view?

Ans. Detail

c. Locate and list one position dimension on Section BB.

Possible Ans. 5/8" or 3/4" or 1/4"

d. Locate and list the scale and date of this drawing

Scale 3/16" = 1" - 3/23/51

2. Each student will answer with 75% accuracy questions concerning mechanical drawing and blue print reading. Instructor will check for accuracy.

   a. What does a center line show?

      Ans. Location of holes

   b. Define tolerance

      Ans. Amount of variation permitted in size and location.

   c. What dimensions does a front view of an orthographic drawing show?

      Ans. True height and length

   d. All letters and figures on AF drawings are placed in what position?

      Ans. Horizontally

3. Instructor will check for accuracy to within 1/32 in. of study guide dimensions.

(Day 1, 6 hrs) END OF DAY SUMMARY

SUMMARY:

1. Purpose of a drawing
2. Identification and use of a drawing
3. Drawing to scale
4. Geometric principles and construction
5. Standard drawing lines
6. Types of drawings
7. Shop drawings and sketches of welded assemblies
8. Sectionalized drawing
9. Cross hatched sections

ASSIGNMENT:

1. Review: 3ABR53131-SG-201
2. Read: 3ABR53131-SG-202
3. Modern Welding Handbook Para 18-13, 18-14 and 18-17

(Day 2, 2 hrs) INTRODUCTION TO NEW DAY'S INSTRUCTION

REMOTIVATION: Need for mechanical drawing and blue prints.

REVIEW:

1. Evaluate outside assignment. Critique missed items.
2. Purpose of a drawing
3. Identification and use of drawing equipment
4. Drawing to scale
5. Geometric principles and construction
6. Standard drawing lines
7. Types of drawings
8. Shop drawing and sketches of welded assemblies
9. Sectionalized drawings
10. Cross hatched sections

OVERVIEW:

1. Interpret shop drawing, diagrams and blueprints
2. Welding symbols

BODY

APPLICATION

2. Each student will construct a shop drawing of the station joint in SG 201 Figure 19

EVALUATION:

Instructor will check for accuracy to within 1/32 in. of study guide dimensions.

CONCLUSION TIME: 10 Min.

SUMMARY:

1. Purpose of a drawing
2. Identification and use of drawing equipment
3. Drawing to scale
4. Geometric principles and construction
5. Standard drawing lines
6. Types of drawings
7. Shop drawings and sketches of welded assemblies
8. Sectionalized drawing
9. Cross hatched sections
10. Welding symbols

ASSIGNMENT:

1. Assignment given at end of day summary.

REMOTIVATION:

CLOSURE:

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 26 Sept 75	INSTRUCTOR
COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER II	BLOCK TITLE Oxyacetylene Welding, Cutting, Soldering, Brazing and Hard Surfacing

LESSON TITLE
Joints of Heat and Corrosion Resistant Ferrous Alloys

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
D & D 2 hrs/Perf 5 hrs	2 hrs	7 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
12	23 Sep 1975	2

STS/CTS REFERENCE

NUMBER	DATE
STS 531X1	31 May 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Oxyacetylene Welding Station Complete 2. Power Shears	Consolidated Toolkit	None	1. 3ABR53131-SG-202 2. TO 34W4-1-5 3. Modern Welding (Chapter 18) 4. TO 1-1A-9 **5. Slides; Stainless Steel Joint Preparation**

CRITERION OBJECTIVES AND TEACHING STEPS **(cont on reverse)**

a. Without reference, identify the types and uses of heat and corrosion resistant ferrous alloys with 75% accuracy.

b. Given oxyacetylene welding equipment, and heat and corrosion resistant ferrous alloy specimens, set up and weld lap joints, free of undercut, oxidation, overlap, and excessive penetration for a total combined distance of no less than 3/4 of the length of the specimen excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.

c. Given oxyacetylene welding equipment and heat and corrosion resistant ferrous alby specimens, set up and weld butt joints with 100% penetration, free of undercut, overlap, and excessive oxidation for a total combined distance of no less than 3/4 of the specimen excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.

LESSON PLAN (Part I, General) CONTINUATION SHEET

CRITERION OBJECTIVES AND TEACHING STEPS (Continued)

d. Given oxyacetylene welding equipment, and heat and corrosion resistant ferrous alloy specimens, set up and weld tee joints free of undercut, overlap, and excessive penetration for a total combined distance of no less than 3/4 of the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.

Teaching steps are listed in Part II.

☆ GPO: 1972 779-380/84

INTRODUCTION Time: 10 min

1. ATTENTION: Talk about Heat & Corrosion Resistant Alloys, Hot Sections of Aircraft engines and Chow Hall Stainless.

2. REVIEW: During our last lesson we learned the purpose and use of drawings and blueprints.

3. OVERVIEW: Upon completion of this lesson you will be able to apply the welding procedures and techniques necessary to make lap, butt and tee joint of heat and corrosion resistant steel.

4. MOTIVATION: Serious responsibility of welders whether in field maintenance or Civil Engineers.

BODY Time: 6 hrs 40 min

PRESENTATION:

1. Types and uses of stainless steel

   a. Distinguish the uses and types of stainless steel.

      (1) Stainless steel probably most important metal in high speed aircraft.

         (a) Heat resistant and maintains strength at high temperature.

         (b) Corrosion resistance.

         (c) High tensile strength.

      (2) Jet age increased the importance of S.S.

      (3) Types and uses.

         (a) Types use mostly in the AF are 321 or 347.

         (b) Type 321 is stabilized by a certain percentage of titanium and in type 347 the stabilizer is columbium.

         (c) This type of stainless steel is used a great deal in the hot section of an aircraft.

2. Setting up and welding lap joints of S.S. SHOW SLIDES

a. Welding procedure.

(1) Clean metal edges and remove burrs.

(2) Fit upper and lower pieces tightly together.

(3) Flux underside of the joint, flux rods.

(4) Tip one or two sizes smaller than for same thickness carbon steel (62)

(5) Adjust flame to slightly carburizing with 1/16" feather.

(6) Tack weld at one inch intervals making tacks as small as possible.

(7) Start at one end and complete weld.

(8) Direct flame mostly on bottom sheet.

(9) Add filler rod near top edge of joint, keeping rod slightly in advance of pool and allowing the molten metal flow into the pool and feather off at end of joint.

(10) Turn work over and weld other side.

(11) Do not remove touch too quickly at the end of weld or oxidation will take place.

(12) Remove all Flux

(13) Check with Instructor.

3. Setting up and Welding butt joints, of S.S

a. Welding procedure.

(1) Clean metal edges and remove burrs.

(2) Square edge may be used on metal thickness up to 1/8 inch.

(3) Spacing should not exceed the metal thickness after tacking.

(4) Tack approximately one inch apart along the entire joint.

(5) Add flux to the bottom edges of the joint, flux rods.

(6) Tip one or two sizes smaller than used on carbon steel.

(7) Welding flame slightly carburizing with 1/16" feather.

(8) Flame directed at 45 degree angle.

(9) Filler rod 20 degree angle.

(10) Do not remove touch too quickly at the end of weld or oxidation will take place.

(11) Remove all Flux.

(12) Check with Instructor.

APPLICATION: 1. Students will set up and weld lap joints of S.S.

2. Students will set up and weld Butt joints of S.S.

EVALUATION: Instructor will check for accuracy IAW TO 34W4-1-5 and observance of all shop safety, good housekeeping and fire prevention measures.

(Day 2, 4 hrs) END OF DAY SUMMARY

SUMMARY

1. Types and uses of Stainless Steel.

2. Setting up and welding lap joints.

3. Setting up and welding Butt joints.

ASSIGNEMENT

1. Review 3ABR53131-SG-202

2. Complete ATCPT 52-4, AF TO System.

(Day 3, 3hrs.) INTRODUCTION TO NEW DAY'S INSTRUCTION

1. Evaluate Outside Assignment Critique Missed Items

2. REMOTIVATION: Responsibility of Welders Performance.

3. REVIEW:

    1. Types and uses of Stainless Steel.

    2. Setting up and welding lap joints.

4 OVERVIEW: Set up and welding of S.S. Butt joints.

PRESENTATION BODY

4. Setting up and Welding Tee Joints of S.S.

    a. Welding procedure.

        (1) Clean the metal to be welded, remove burrs.

        (2) Tack every inch.

        (3) Flux the underside and back side of the joint and filler rods.

        (4) Use it Spacers.

        (5) Adjust the flame to slightly carburizing with 1 16" feather.

        (6) Tack weld at 1" intervals.

        (7) Weld by the fore hand method directing most of flame on the bottom sheet.

        (8) Add rod to upper part of the joint keeping the rod within the limits of the flame and allowing molten metal to flow into the pool.

        (9) Feather off at the end of the weld.

        (10) Remove all Flux.

(11) Check with Instructor.

APPLICATION: 1. Students will set up and weld butt joints of S.S.

2. Student will set up and weld tee joints of S.S.

EVALUATION: Instructor will check for accuracy IAW TO 34W4-1-5 and observance of all shop safety, good housekeeping and fire prevention measures.

EVALUATION: Each student will answer with 75% accuracy questions concerning the types and uses of S.S. Instructor will check for accuracy.

1. Name one type of S.S. that is commonly used by the AF.

321 or 347

2. What stabilizer is used in your answer to the first question?

321		347
Titanium	or	Columbian

3. Which TO will be consulted to find the types and uses of various types of S.S.?

TO 1-1A-9 Aerospace Metals and usage factors.

4. Which series S.S. is called Austenitic S.S.?

300 Series

CONCLUSION

Time: 10 min

1. Summary

   1. Types and uses of Stainless Steel.
   2. Setting up and welding lap joints of S.S.
   3. Setting up and welding butt joints of S.S.
   4. Setting up and welding tee joints of S.S.

2. Assignment: Given at end of Day Summary.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI	INSTRUCTOR
COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER II	BLOCK TITLE Oxyacetylene Welding, Cutting, Soldering, Brazing and Hard Surfacing

LESSON TITLE
Cutting Carbon Steel

LESSON DURATION

CLASSROOM /Laboratory D & D 1 hr/Perf 5 hrs	Complementary None	TOTAL 6 hrs

POI REFERENCE

PAGE NUMBER 14	PAGE DATE 23 Sep 1975	PARAGRAPH 4

STS/CTS REFERENCE

NUMBER STS 531X1	DATE 31 May 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Oxyacetylene Welding & Cutting Torch Kit 2. Straight Line Cutting Machine 3. Oxyacetylene Welding Station Complete	Toolkit	None	1. 3ABR53131-SG-204 2. TO 34W4-1-5 3. Modern Welding (Chapters 3 and 4)

(cont on reverse)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without reference, identify the factors pertaining to oxyacetylene cutting operations with 75% accuracy.

b. Given oxyacetylene cutting equipment and carbon steel specimens, cut up and perform cutting operations free of excessive burrs and undercut sections for a total combined distance of no less than 3/4 of the length of the specimen. All shop safety, good housekeeping, and fire prevention measures must be observed.

Teaching steps are listed in Part II.

ATC FORM AUG 72 770

☆ GPO: 1972 779-398/23

INTRODUCTION

Time: 10 min

1. Attention:

2. Review: During our last lesson we learned the USAF TO System and use of indexes.

3. Overview: Upon completion of this lesson will be able to apply the techniques and procedures of oxyacetylene cutting.

4. Motivation:

BODY

Time: 5 hrs 40 min

Presentation:

1. Factors pertaining to oxyacetylene cutting
    a. Principles of oxyacetylene cutting
        (1) Oxyacetylene cutting is the rapid oxidation of the metal in a localized area.
            (a) The metal is heated to a bright (cherry) red temperature.
            (b) A jet of high pressure oxygen is forced against the hot metal causing a narrow slot or "Kerf" to separate the metal.
    b. Cutting Torch
        (1) Something like welding torch
        (2) Has three tubes
            (a) Preheating oxygen
            (b) Preheating acetylene
            (c) Cutting oxygen tube

(3) Cutting Tips

(a) Differ from welding tip

1 Has as many as 2 to 9 orifices

2 Four preheating orifices

3 One (1) cutting oxygen orifice

(4) Maintenance of cutting tips

(a) Accumulation of slag will sometimes occur on tip

(b) Remove slag, fasten torch in vise using a soft material or a wood block on face of jaws to prevent damage to the torch and tubes

(c) Remove the slag by using a fine emery cloth or fine file

(d) Select a tip cleaner two (2) sizes smaller than the tip orifices and clean by moving tip cleaner up and down. (Caution) Do not twist as this may break the tip cleaner in the orifice

c. Safe cutting procedures

(1) Never do any cutting on used drums, barrels, tanks, or other containers until they have been thoroughly cleaned

(2) Cleaning

(a) Steam should be used if available

(b) Steam for a minimum of three (3) hours

(c) Flusing with hot water for one (1) hour is permissable but not recommended

(3) Move all combustible material

(a) To a safe distance

(b) Or move work to a safe distance from combustible material

(4) Never cut material in such a position **that it might permit** sparks, hot metal or severed sections to fall on gas cylinders hoses, legs or feet

(5) Care must be taken to prevent slag from clogging cutting orifices which will occur if torch is held too close to the work

2. Cutting carbon steel

a. Procedures for cutting carbon steel

(1) Plain carbon steel with a carbon content of 0.35% or less will cut readily without special precautions other than those cutting procedures required for cuts of good quality

(2) Connect cutting attachment

(3) Open torch oxygen valve fully

(4) Light torch, adjust preheat flame to neutral

(5) Depress cutting oxygen lever fully readjust preheating flames to neutral with valve on cutting attachment. Release cutting oxygen lever

(6) Hold the torch 90° to the work, heat to a cherry red

(7) Slowly depress the cutting oxygen lever to its fully open position

(8) Move as fast as possible without losing the cut

(9) In case the metal stops separating move the torch back, re-heat then continue cutting

INTERIM SUMMARY

b. High Alloy Steels

(1) Preheat to approximately 55° F. to prevent the metal from forming a hard layer along the edge of cut

c. Beveling carbon steel with a cutting torch

(1) Torch control more difficult than square edge cutting

(2) Speed of travel and steadiness of hand are important to obtain a smooth even bevel

(3) A line made with chalk can be used to indicate the top edge of the bevel

(4) A piece of angle iron can be clamped into position to aid in proper torch angles and can be used as a rest to insure steadiness

d. Cutting of round stock

(1) Raise a burr on the stock using a hammer and a chisel. This will help start the cut without prolonged heating

(2) After the cut is started, the torch is raised to the vertical position for the remainder of the cut

(3) The preheating flame is the same distance from the surface as in cutting flat stock

e. Pipe cutting

(1) The simplest cut is the square cut as in preparation of a butt joint

(2) Using either chalk or a center punch to make a line around the pipe where the cut is to be made

(3) The cut is started at the top center of the pipe and carried down to the bottom center line

(4) When cut is in **progress** the torch should be constantly pointed to the axis of the pipe

(5) When bottom point has been reached, raise the torch and restart at the top to complete the cut

f. Flame gouging

(1) Flame gouging is used for quick and accurate removal of a narrow strip of surface metal from steel plates, forgings and castings

(2) This differs in flame cutting in that the cutting action does not penetrate through the metal

(3) Flame gouging can be used for removing cracked welds or grooving metal that is cracked to insure good penetration when it is repaired by welding

(4) Special curved tips are used for flame gouging

g. Circular cutting

(1) Flame is used as would be used on free hand cutting of the same material

(2) Done with either hand torch or machine torch

(3) Rate of travel is determined by the type and thickness of the metal being cut

(4) For cutting with a hand torch a circular cutting attachment should be used

(a) The attachment consists of a rod with a clamp attached to the torch head. An adjustable center point on the other end may be set to the desired radius

(b) The cutting attachment can be locally manufactured with the aid of the machine shop

h. Machine cutting

(1) The principles of flame cutting are the torch is manually or mechanically controlled

(2) Machine flame cutting advantages

(a) Better workmanship

(b) Greater accuracy

(c) Lower cost

3. Cutting Equipment Maintenance

INTERIM SUMMARY

EVALUATION: Each student will answer with 75% accuracy questions pertaining to oxyacetylene cutting operations. Instructor will check for accuracy.

1. Define Kerf

The narrow slot that separates the metal

2. How many cutting oxygen orifices does a cutting tip have?

One

3. Before cutting a barrel, how many hours minimum should it be steam cleaned?

   Three

4. While cutting, hold the torch approximately how far from the metal?

   1/8"

END OF DAY SUMMARY

SUMMARY

1. Factors pertaining to oxyacetylene cutting
2. Perform oxyacetylene cutting operations
3. Cutting equipment maintenance

ASSIGNMENT

Review: 3ABR53230-SG-204
3ABR53230-WS-204

Read: Modern Welding Handbook Chapter 15
3ABR53230-SG-205
3ABR53230-WS-205

Complete: ATCPT 52-1 VOL I Maint. Mangt.
ATCPT 52-1 VOL II Maint. Mangt.

INTRODUCTION TO NEW DAY'S INSTRUCTION

1. Remotivation:

2. Review:

   1. Factors pertaining to oxyacetylene cutting
   2. Cutting carbon steel
   3. Cutting equipment maintenance

Presentation (Continued)

APPLICATION: Students will perform oxyacetylene cutting operations and operator maintenance on equipment

EVALUATION: Instructor will assist when necessary check for accuracy IAW 34W4-1-5, and check for observance of all shop safety, good housekeeping and fire prevention measures

CONCLUSION

Time: 10 min

SUMMARY:

1. Factors pertaining to oxyacetylene cutting
2. Cutting carbon steel
3. Cutting equipment maintenance

ASSIGNMENT: Given at end of Day Summary

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 26 [illegible]	INSTRUCTOR
COURSE NUMBER BR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER II	BLOCK TITLE Oxyacetylene Welding, Cutting, Soldering, Brazing and Hard Surfacing

LESSON TITLE
Silver and Lead Soldering

LESSON DURATION

CLASSROOM/Laboratory D & D 1 Hr/Perf 1.5hrs.	Complementary None	TOTAL 3 hrs

POI REFERENCE

PAGE NUMBER 15	PAGE DATE 23 Sep 75	PARAGRAPH 5

STS/CTS REFERENCE

NUMBER STS 531X1	DATE 31 May 75

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Oxyacetylene Welding Station Complete 2. Power Shears 3. Trainer: Hard & Soft Solder Joints, 4406	Consolidated Toolkit	None	1. 3ABR53131-SG-205 2. TO 34W4-1-5 3. Modern Welding (Chapters 15 & 16)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without reference, identify the principles and techniques of lead and silver soldering with 75% accuracy.

b. Given oxyacetylene welding equipment and metal specimens, set up and solder lap and tee joints with 100% adhesion, free of excessive overlap and oxidation for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire preventinn measures must be observed.

Teaching steps are listed in Part II.

☆ GPO: 1972 770-388/23

INTRODUCTION

Time: 10 Min

ATTENTION:

REVIEW: During our last lesson we learned the factors and techniques oxyacetylene cutting.

OVERVIEW: Upon completion of today's lesson you will be able to apply the principles and techniques of silver and lead soldering.

MOTIVATION:

BODY

Time: 2 hrs 40 min

PRESENTATION:

1. Principles and techniques of silver soldering

    a. A process in which bonding is produced by heating the base metal to a temperature between 1145° and 1650° F and adding a silver alloy filler metal with a melting point within this temperature range

        (1) Will bond most ferrous and nonferrous metals

        (2) Is a free flowing metal in the molten state

        (3) Melts at a lower temp than the parentmental

        (4) Can be sweated into a tight joint

        (5) There are several types of silver solder with the silver content ranging from 10 to 80% and having a melting point from 1145° to 1650°F

        (6) Silver solder is obtained in rod, strip, wire and granulated form

b. Joints designed for silver solder

(1) Important factors

(a) Type of metal to be joined

(b) Service requirements of joints

(c) Type of joint used

(d) Fit up and results obtained differ from that of a fusion weld

(e) Silver solder should not be used as a filler inbeveled type joints

(f) These alloys flow freely into narrow openings

(g) Recommended joint clearance is .002 to .005 inches

c. Preparation of joints

(1) Cleaning: A clean oxide free surface is very important to insure quality and a sound joint

(a) All grease, oil, dirt and other oxides should be removed from base metal and filler rod to insure a good bond throughout the joint

(b) For rust and heavy oxide, sand blasting can be used

(c) Grease and oil can be removed by trichlorethylene and trisodium phosphate

(d) Other cleaning agents or machines & grinders, buffers, emery cloth, vapor degreasers, files and some acids

(e) All plating should be removed to insure good bonding

(2) It is recommended that the soldering process be performed as soon as possible after cleaning

d. Fluxes

(1) Fluxes serve a dual purpose in effecting strong uniform soldering joints and is a must when silver soldering

(a) React with surface films, reducing them giving a clean surfact to the molten silver solder

(b) Form protective films during the soldering cycle thus preventing reoxidation at elevated temperatures required for soldering

(c) Assist the silver to flow freely

2. Silver soldering various types of joints

a. Clean surface of metal

b. Flux surfaces to be joined together

c. Align pieces, overlap a minimum of 3T

d. Soft neutral to slightly carburization flame, use outer envelope of flame

e. Heat joint until flux starts to melt, apply filler material, continue heating just long enough to flow the filler metal completely into the joint

f. Keep the torch in motion

g. Remove flux

Interim Summary

3. Principles and techniques of lead soldering

a. The soft solder process is used for joining most common metals with an alloy that melts at a temperature below that of the base metal and always below 800°F

b. For its strength, the soldered joint depends on the penetration of the solder into the pores of the base metal surface and the consequent formation of a base metal solder alloy, together with the mechanical bond between the parts

c. Soft solder compositions

  (1) Composed principally of lead and tin with or without the addition of antimony, arsenic, or bismuth to impart desired qualities

  (2) In general, the higher the lead content, the higher the melting point

  (3) High-lead solder for joints subjected to temperatures as high as 400°F

  (4) High tin solder has a lower melting point, used for joining low-melting point fusable alloys

d. Fluxes

  (1) Corrosive and non-corrosive

  (2) To remove and exclude small amounts of oxides and other impurities from the joint being soldered

    (a) Prevents re-oxidation of the surface when heated

    (b) Lowers surface tension

    (c) Flux is readily displaced by the solder

4. Cleaning

  a. Chemical

  b. Mechanical

Interim Summary

5. Lead soldering various types of joints to instructor specifications

   a. Clean metal

   b. Apply flux

   c. Tin areas of the base metal to be joined together

   d. Align the joint

   e. Apply heat, soft neutral flame, outer envelope, keep torch in motion

   f. Apply solder

   g. Lead solder will flow into space by capillary attraction

   h. Remove all traces of flux

   i. Observe all shop safety, good housekeeping and fire prevention measures in performance of required tasks

Interim Summary

APPLICATION: Instructor will administer Appraisal Test identifying principles and techniques of lead and silver soldering.

EVALUATION: Each student will answer with 75% accuracy, questions concerning the principles and techniques of lead and silver solder. Instructor will check for accuracy.

1. What is the melting point rante for silver solder?

   1145°F to 1650°F

2. What is the recommended silver solder joint clearance?

   .002" to .005"

3. What type flame is used for soft soldering?

   Soft neutral

4. Soft solder always melts below what temperature?

   800°F

END OF DAY SUMMARY

(Day 5, 1 hr)

SUMMARY:

1. Principles and techniques of silver soldering
2. Silver soldering various type of joints
3. Principles and techniques of lead soldering
4. Cleaning
5. Lead soldering various types of joints

ASSIGNMENT:

Review: 3ABR53230-SG-205

Complete: ATCPT 52-1 VOL III Maint. Mangt.
ATCPT 52-1 VOL IV Maint. Mangt.

Read: 3ABR53230-SG-206 and answer questions

INTRODUCTION TO NEW DAY'S INSTRUCTION

Day 6, 2 hrs)

1. Evaluate outside assignment and critique missed items
2. REMOTIVATION: AF Aircraft, cannon plugs and other parts
3. REVIEW:
   a. Principles and techniques of silver soldering
   b. Silver soldering various types of joints
   c. Principles and techniques of lead soldering

d. Cleaning

e. Lead soldering various types of joints

4. OVERVIEW: Lead and silver soldering various types of joints

PRESENTATION (Continued)

APPLICATION: Students will set up and solder various joints

EVALUATION: Instructor will assist when necessary, check for accuracy IAW T034W4-1-5 and check for observance with all shop safety, good housekeeping and fire prevention measures

CONCLUSION

(Day 6, 2 hrs) Time: 10 min

SUMMARY:

1. Principles and techniques of silver soldering
2. Silver soldering various types of joints
3. Principles and techniques of lead soldering
4. Cleaning
5. Lead soldering various types of joints

ASSIGNMENT: Given at end of day summary

REMOTIVATION:

CLOSURE:

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 26 Sept 75	INSTRUCTOR
COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER II	BLOCK TITLE Oxyacetylene Welding, Cutting, Soldering, Brazing and Hard Surfacing

LESSON TITLE
Brazing Steel and Gray Iron Castings

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
D & D 2 hrs/Perf 5 hrs	2 hrs	9 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
18	23 Sep 1975	8

STS/CTS REFERENCE

NUMBER	DATE
STS 531X1	31 May 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Oxyacetylene Welding Station Complete 2. Grinders and Buffers	Toolkit	None	1. 3ABR53131-SG-208 2. TO 34W4-1-5 3. TO 34W4-1-7 4. Modern Welding (Chapter 16) 5. Film: Braze Welding Beads

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without reference, identify the mechanical properties produced by brazing ferrous castings and ferrous wrought products with 75% accuracy.

b. Given oxyacetylene welding equipment and gray iron castings, set up and braze butt joints with 100% adhesion, free of excessive oxidation and overlap for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.

c. Given oxyacetylene welding equipment and carbon steel specimens, set up and braze butt joints with 100% adhesion, free of excessive oxidation and overlap for a total combined distance of no less than 3/4 the length of the specimen excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.

Teaching steps are listed in Part II.

INTRODUCTION Time: 10 min

1. Attention:

2. Review: During our last lesson we learned the USAF Inspection and Maintenance System and use of the Man-hour Reporting and Maintenance Data Collection System.

3. Overview: Upon completion of lesson, you will be familiar with the fundamental principles and be able to apply the techniques of brazing steel and cast iron.

4. Motivation:

BODY Time: 6 hrs 40 min

PRESENTATION

1. Mechanical properties produced by brazing

   a. Stronger than a soldered joint

   b. Is used where mechanical strength and pressure proof joints are desired

   c. It does not affect the heat treatment of metals as much as fusion welding

   d. Used to join dissimilar metals

2. Brazing is an adhesion process in which the metals being joined are heated but not melted; the brazing filler metal melts and flows at temperatures above 800 degrees F.

   a. Advantages

      (1) The fact that brazing is done without melting the base metal greatly simplifies the repair procedure.

(2) Due to lower temperatures required when brazing, expansion and contraction are less.

(3) Brazing is also the only practicle method of repairing malleable and white cast iron castings.

(4) Brazed joints are more ductile than fusion welded joints.

3. Brazing rod

   a. Nonferrous alloy used as a filler material.

   b. Composed chiefly of copper, zinc and tin.

   c. Melting temperatures range from approximately 970°F to 2030°F.

4. Flux

   a. Material used to prevent, dissolve or facilitate removal of oxides and other undesirable substances.

   b. Keeps both the brazing filler metal and the metals being joined clean during the brazing operation.

   c. Powdered and or liquid form.

Interim Summary

5. Gray cast iron and Carbon steel

   a. Gray cast iron

      (1) Contains 90-94% pure iron.

      (2) Very fluid when molten, solidifies slowly, ideal for castings or intricate design.

      (3) Brazed or fusion welded satisfactorily.

   b. Carbon steels

      (1) All carbon steels braze satisfactorily.

      (2) Low

      (3) Medium

(4) High

6. Brazing Gray Cast Iron and Carbon Steel Butt Joints

   a. Procedures

      (1) Clean metal

         (a) Grind or wire brush edges

         (b) Remove surface dirt and grease at least one (1) inch on each side of joint.

         (c) Clean with a grease solvent dry cleaning solvent, mineral spirits paint thinner.

         (d) Sear edges with an oxidizing flame

      (2) Bevel all joints

         (a) Use grinder

         (b) Checking grinding wheel for nicks or crack

         (c) Check rests for distance from wheel

         (d) Round all sharp edges

      (3) Select tip size

         (a) One size larger than would be used for fusion welding steel the same thickness .

      (4) Select filler rod

         (a) According to filler table

         (b) Select to right composition

         (c) Filler rod is composed of copper, tin and zinc.

      (5) Flame adjustment

- (a) Slightly oxidizing flame for tinning
- (b) An oxidizing flame is used also when a layer of bronze does the job sufficiently.
- (c) If two or more layers of bronze are used, flame should be neutral.

(6) Pre-heat

- (a) Pre-heat cast iron
  - 1 Approximately 1200F full red heat
  - 2 Small parts can be pre-heated with torch
  - 3 Large parts should be pre-heated in a furnace
- (b) Pre-heat carbon steel
  - 1 Approximately 1200F (cherry red)

(7) Flux

- (a) Use a liberal amount of flux when tinning the base metal
- (b) After the tinning process is completed the flux should be used sparingly to avoid too much reduction of the oxide film covering the molten pool

(8) Applying the filler rod

- (a) Central cone is held from 1/8 to 1/4" away from surface metal
- (b) The flame is pointed ahead of the deposit at an angle of about 45°
- (c) When base metal is too cold the bronze will not spread

(9) Tinning the base metal

    (a) Thin layer of bronze over the area to be brazed

(10) When base metal is too hot the bronze will ball up and vapors will rise from the work. You are burning the zinc out of the bronze.

(11) Brazing should not be used on castings subject to temp higher than 650°F.

(12) Cooling

    (a) Cast Iron

        1 Small parts should be cooled at room temp covered with asbestos if possible

        2 Large parts should be cooled in furnace with all openings in furnace sealed. Furnace should be runup to specified temperature. Place part in furnace than turn furnace off-parts, cool as the furnace cools.

    (b) Carbon Steel

        1 No particular method of cooling

(13) Removing Flux

    (a) Use chipping hammer

    (b) Use wire brush

Interim Summary

(14) Brazing fumes can be highly toxic, assure adequate ventilation.

(15) Some of cleaning solvents are in flammable, assure adequate fire prevention measures.

Interim Summary

APPLICATION: Students will set up and braze carbon steel butt joints

EVALUATION: Instructor will assist when necessary check for accuracy IAW TO 34W4-1-5, and check for observance of all shop safety, good housekeeping and fire prevention measures.

END OF DAY SUMMARY

SUMMARY

1. Mechanical properties produced by brazing
2. Brazing definition, advantages
3. Brazing Rod
4. Flux
5. Gray Cast Iron & Carbon Steel
6. Brazing Gray Cast Iron & Carbon Steel Butt Joints

ASSIGNMENT:

Review: ATCPT 52-1 VOL I, II, III, V
3ABR53230-SG-208
3ABR53230-WS-208

Read: 3ABR53230-SG-209

Complete: 3ABR53230-WS-209

Read: Modern Welding Handbook Paragraph 24-7

INTRODUCTION TO NEW DAYS INSTRUCTION

1. Remotivation: Do 100% job on any brazing job
2. Review:
    1. Mechanical properties produced by brazing
    2. Brazing definition

3. Brazing Rod
4. Flux
5. Gray Cast Iron and Carbon Steel
6. Brazing Gray Cast Iron and Carbon Steel Butt Joints

PRESENTATION (Continued)

APPLICATION: Students will set up and braze butt joints of Gray Cast Iron

EVALUATION: Instructor will assist when necessary, check for accuracy IAW TO 34W4-1-5, and check for observance of all shop safety, good housekeeping and fire prevention measures.

EVALUATION: Each student will answer with 75% accuracy questions concerning the properties produced by brazing ferrous castings and ferrous wrought products. Instructor will check for accuracy.

1. Is brazing stronger than a soldered joint?

   Ans. Yes

2. When is brazing used?

   Ans. When mechanical strength or pressure proof joints are desired.

3. Does brazing affect the heat treatment of metals as much as fusion welding?

   Ans. No

4. Can brazing be used to join dissimilar metals?

   Ans. Yes

CONCLUSION Time: 10 min

SUMMARY

1. Mechanical properties produced by brazing

2. Brazing definition
3. Brazing Rod
4. Flux
5. Gray Cast Iron and Carbon Steel
6. Brazing Gray Cast Iron and Carbon Steel Butt Joints

ASSIGNMENT: Given at end of Day Summary

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE STI 26 Sept 75	INSTRUCTOR
COURSE NUMBER 3ABR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER II	BLOCK TITLE Oxyacetylene Welding, Cutting, Soldering, Brazing and Hard Surfacing

LESSON TITLE
Fusion Welding Ferrous Castings

LESSON DURATION

CLASSROOM /Laboratory D & D 1½ hr/Perf 4.5 hrs	Complementary 2 hrs	TOTAL 8 hrs

POI REFERENCE

PAGE NUMBER 19	PAGE DATE 23 Sep 1975	PARAGRAPH 9

STS/CTS REFERENCE

NUMBER STS 531X1	DATE 31 May 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Oxyacetylene Welding Station Complete 2. Grinding Machines	Consolidated Toolkit	None	1. 3ABR53131-SG-209 2. TO 34W4-1-5 3. TO 34W4-1-7 4. Modern Welding (Chapter 18)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without reference, identify the mechanical properties and uses of various types of cast iron with 75% accuracy.

b. Given metal specimens and grinding equipment, set up and identify cast iron castings by spark testing without error. All shop safety, good housekeeping, and fire prevention measures must be observed.

c. Given oxyacetylene welding equipment and metal specimens, set up and fusion weld butt joints of gray cast iron, with 100% penetration, free of undercut and overlap for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention must be observed.

Teaching steps are listed in Part II.

INTRODUCTION

Time: 10 min

1. Attention:

2. Review: During our last lesson we learned fundamental principles and techniques of brazing steel and cast iron.

3. Overview: Upon completion of this lesson you will be familiar with the fundamental principles and be able to apply the technique of fusion welding cast iron.

4. Motivation:

BODY

Time: 5 hrs 40 min

PRESENTATION

Discussion, Demonstration, Performance

1. Mechanical properties and uses of various types of cast iron.

   a. Cast Iron In General

      (1) Product of Cupola Furnace

      (2) Type of cast iron produced is determined by rate of cooling from the molten state

      (3) Composed of iron

      (4) Composed of between 2.25 and 4.0% carbon

      (5) Possesses low tensile strength

      (6) Possesses high compression strength

      (7) Used extensively for heavy machine parts

   b. White Cast Iron is Gray Cast Iron

      (1) Cooled rapidly from molten state

(2) Silvery white in appearance

(3) Mechanical properties:

(a) Wear resistance

(b) Hard and brittle

(4) Only method of repair is brazing

c. Malleable Cast Iron

(1) Produced by heating white cast iron to about 1650°F, holding it at this temperature for several hours or days and then cooling it slowly.

(2) Dull gray in appearance and somewhat lighter in color than gray cast iron

(3) Mechanical properties:

(a) Can be bent slightly without breaking

(b) Shock resistance

(c) Best method of repair is brazing

d. Gray Cast Iron

(1) Cooled slowly from molten state

(2) Dull Gray appearance

(3) Mechanical Properties:

(a) Weight

(b) Rigidity

(4) Only Cast Iron that can be repaired by fusion welding or brazing.

2. Spark Test IAW TO 34W4-1-5

a. Bring Metal in contact with high speed grinding wheel

  (1) Check characteristics of complete spark stream carefully.

  (2) Spark stream will vary in one more of the following; color, density, shape and length

  (3) Positive identification can be made by comparing the spark stream of an unknown metal with those of a known metal

  (4) Spark test charts are also available

  (5) White Cast Iron

    (a) Volume very small

    (b) Length 20"

    (c) Color close to wheel - red

    (d) Color at end of stream - straw

    (e) Quanity of spurts - few

  (6) Mallable Cast Iron

    (a) Volume moderate

    (b) Length 30"

    (c) Color Close to wheel - red

    (d) Color at end of stream - straw

    (e) Quantity of spurts - many

  (7) Gray Cast Iron

    (a) Volume small

    (b) Length 20"

    (c) Color close to wheel - Red

        (d) Color at end of stream - Straw

        (e) Quantity of Spurts - Many

3. Chip Test

    a. Distinguishes one type of Cast Iron from another

    b. A narrow chip is cut from the part with a chisel

    c. The ease with which the metal can be chipped and the form of the chip gives a means of identification

    d. TO 34W4-1-5 gives specific identification of each type cast iron using the chip test

4. Fusion welding of gray cast iron butt joints

    a. Preparing the metal for fusion welding

        (1) Clean metal

            (a) Sand blast can be used for removing rust or heavy coating of oxide

            (b) Solvent can be used for removing rust or heavy coating of oxide

        (2) Bevel metal

            (a) If the metal is heavier than 1/8" cross section, the edges are to be beveled

            (b) Cracks or breaks that cannot be removed for beveling can be chipped out with a round nose or diamond point chisel.

            (c) They may also be ground out with a flexible grinder.

- (d) Should a crack start to extend when heat is applied, stop drill to prevent its spreading.

(3) Grind off sharp edges

- (a) Use portable grinder

(4) Pre-heat

- (a) Depends on type and shape of castings as well as the nature of the break.
- (b) Large castings such as cylinder parts usually pre-heat the entire unit before making a fusion weld.
- (c) Small casting local pre-heat is adequate.
- (d) The pre-heat temp for gray cast is approximately 1200F.

(5) Flux Rod

- (a) Use flux on rod at all times on fusion welding

(6) Tack

- (a) Tack should be made on each end of the metal and also on the center.

(7) Torch techniques

- (a) Tip should be one size larger than used for steel the same thickness.
- (b) This will help keep from blowing moltenmetal ahead on cold surfaces of the joint.

(c) Caution must be taken also to prevent burning out the bottom of the vee too rapidly.

(d) The tip of the central cone is held approx. 1/8" to 1/4" away from the molten pool.

(8) Neutral flame

(9) Backhand welding

(10) Stir molten pool with rod

(11) Cool slowly

Interim Summary

APPLICATION: Each student will identify various cast iron specimens, utilizing grinders.

EVALUATION: Instructor will check for accuracy IAW TO 34W4-1-5, observance of all shop safety good housekeeping and fire prevention measures.

(Day 9, 5 hrs)

END OF DAY SUMMARY

SUMMARY

1. Mechanical properties and uses of various types of cast iron
2. Spark test
3. Chip test
4. Fusion welding of gray cast iron butt joints

CTT ASSIGNMENT:

Review: 3ABR53230-SG-209

Read: 3ABR53230-SG-210

Start review of notes, study guides, 201 - 205 Inclusive for Block Test

ATCPT on TOs

(Day 10, 1 hr) INTRODUCTION TO NEW DAYS INSTRUCTION

1. Evaluate CTT Assignment and Critique Missed Items.

2. Remotivation: Must avoid over heating, warpage & distortion.

3. Review:

   1. Mechanical properties and uses of various types of cast iron
   2. Spark Test
   3. Chip Test
   4. Fusion Welding of gray cast iron butt joints

PRESENTATION (Continued)

APPLICATION 2: Each student will set up and fusion weld gray cast iron butt joints.

EVALUATION 1. Instructor will check for accuracy IAW TO 34W4-1-5, observance of all shop safety, good housekeeping and fire prevention measures. Instructor will assist students when necessary.

2. Instructor will administer appraisal test. Student will answer with 75% accuracy questions concerning mechanical properties and uses of various types of cast iron.

CONCLUSION

Time: 10 min

SUMMARY

1. Mechanical properties and uses of various types of cast iron
2. Spark Test
3. Chip Test
4. Fusion welding of gray cast iron butt joints

ASSIGNMENT: Given at end of Day Summary

Remotivation:

Closure:

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 26 Sept 75	INSTRUCTOR
COURSE NUMBER BR53131	COURSE TITLE Metals Processing Specialist
BLOCK NUMBER II	BLOCK TITLE Oxyacetylene Welding, Cutting, Soldering, Brazing and Hard Surfacing

LESSON TITLE
Hard Surfacing

LESSON DURATION

CLASSROOM /Laboratory	Complementary	TOTAL
D & D 1.5hr/Perf 1.5hrs	None	3 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
20	23 Sep 1975	10

STS/CTS REFERENCE

NUMBER	DATE
STS 531X1	31 May 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Oxyacetylene Welding Station Complete 2. Grinders and Buffers	Consolidated Toolkit	None	1. 3ABR53131-SG-210 2. TO 34W4-1-5 3. Modern Welding (Chapter 20)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without reference, identify the purpose, types, and mechanical properties of hard surfacing materials with 75% accuracy.

b. Given oxyacetylene welding equipment and carbon steel specimens, set up and perform hard surfacing operations, free of excessive undercut, overlap, and porosity for a total combined distance of no less than 3/4 the length of the specimen, excluding the first 1/2 inch start and the last 1/2 inch finish. All shop safety, good housekeeping, and fire prevention measures must be observed.

c. Given hard surfaced specimens and grinding equipment, set up, grind, and finish hard surface deposit to a smooth, even surface no greater than 3/32 of an inch over the entire area of the specimen. All shop safety, good housekeeping, and fire prevention measures must be observed.

Teaching steps are listed in Part II.

ATC FORM AUG 72 770

☆ GPO: 1973 779-398/23

INTRODUCTION

Time: 10 min

1. Attention:

2. Review: During our last lesson we learned the fundamental principles and proper procedure of welding cast iron. (Fusion)

3. Overview: Upon completion of todays lesson you will be able to apply the fundamental principles of hard surfacing and be able to hard surface carbon steel.

4. Motivation:

BODY

Time: 2 hrs 40 min

PRESENTATION:

1. Purpose, types and mechanical properties of hard surfacing materials
    - a. Hard surfacing is used to extend the life of a part, the overlay may contribute
        - (1) Hardness
        - (2) Abrasion resistance
        - (3) Impact resistance
        - (4) Heat resistance
        - (5) Corrosion resistance
        - (6) Antifriction properties
    - b. Metals which can be "hardfaced"
        - (1) Most steels and steel alloys may be hard surfaced

(2) Some high vanadium steels and high speed tool steels cannot be hard surfaced

2. Job requirements to consider

   (1) The nature and cause of wear

   (2) Metal surfacing material needed to reduce this wearing condition

   (3) The process most economical for application

Interim Summary

3. To meet the various requirements many types of hard facing alloy have developed, for simplification these alloys are generally classified into five broad groups

   a. Group I:

      (1) Consist of an iron base and has less than 20% of alloying elements

      (2) Has greater wear resistance than any machine steel

      (3) Although not as hard they have greater toughness and shock resistance than other hard-facing alloys

      (4) They are used to build up badly worn sections before applying a final harder surface with a better grade of hard facing alloy

      (5) Stoodex and Stoody self-hardening are rods which fall into this group

   b. Group II:

      (1) Iron base having 50 to 80% iron and more than 20% alloying elements

(2) These alloys are used for the final hard wear resisting surface after the part has been built up with strength rod

(3) Stoodite and haschrome are types of rods used for this application

(4) For metal to metal friction and severe abrasion (Gears)

c. Group III:

(1) Consists of nonferrous alloys of cobalt, chromium and tungsten

(2) Silfram and stellite are the hardsurfacing rods found in this class

(3) Toughness and strength

(4) This material is used extensively for the valve seats in internal combustion engines

d. Group IV:

(1) This group of alloys consist of so called carbide materials of diamond substitutes and are the hardest and most wear resistant of all hard facing materials

(2) Mainly tungsten carbide 90 - 95%

(3) The remainder being cobalt, nickel and iron or similar metals

(4) Extreme earth abrasion and earth cutting operation

(5) Cobalt, nickel and iron give strength, toughness, heat resistance and impact strength to the tungsten carbide.

(6) Some of the alloys are almost pure tungsten carbide no alloying elements

(7) Alloy of this group is in form of small casting

(8) They are welded on to the wearing surface by means of other metals

(9) Use rod borium and cobalt borium

e. Group V:

(1) This group of alloying consists of crushed tungsten carbides of various sizes

(2) May be fused to strips of mild steel tubes of various diameters

(3) May be applied to wearing surfaces as welding rod

(4) Crushed tungsten carbide are also available in loose form as granular pieces or powder

(5) Can be sprinkled on wearing surface and melted into it

(6) More expensive but has a longer life

(7) Tube borium and borod are some of the types in the group 5 classes

(8) Rods used are borium and cobalt borium

(9) Extreme earth abrasion on small parts on thin sections

Interim Summary

4. Preparation of metal for hard surfacing

a. Must be clean of all scale, rust, dirt or other foreign matter.

- (1) Grinding
- (2) Machining
- (3) Chipping
- (4) When these methods are not available use:
  - (a) Filing
  - (b) Wire brush
  - (c) Sandblasting
- (5) The latter methods are not recommended due to leaving small particles of foreign matter on the surface of the metal which has to be floated out during the hard-facing operation.
- (6) All edges of grooves, corners, or recesses must be rounded to prevent overheating.

b. Pre-heating

- (1) Same in hard-facing as in welding
  - (a) Steels in the heat treated condition should be annealed
  - (b) Quenching in water will crack the hard facing layer
  - (c) Quench in oil if it is necessary

c. Fluxes: Used when there is more than one layer of alloy necessary.

- (1) This helps to remove scale and oxides formed on the base metal
- (2) This applies to cast iron, a cast iron flux may be used

(3) Flux permits gas, oxides and slag inclusions to come to the surface

(4) This will result in a hard and solid surface layer

d. Thickness of deposit

(1) In most cases, the hard facing deposits range from 1/16 to 1/4" in thickness

(a) Depends upon specific application

5. Hard surfacing carbon steel

a. Select tip two sizes larger than for welding

b. Adjust to carburizing flame

c. Torch angel 45°, rod angle 45°

d. Bring metal up to sweating temperature approximately white heat or 2200°F

e. Apply hard surface rod in similar manner as brazing rod

6. Finishing and brinding hard surface deposit

Interim Summary

a. Check for cracks in deposit

b. Inspect for insufficient edge buildup and burned deposits

c. Grind off approximately 1/2 of the deposit and inspect for porosify

APPLICATION:

1. Students will set up and hard surface carbon steel.
2. Students will grind and finish hard surfacing deposits.

EVALUATION:

1. Instructor will assist when necessary, check accuracy IAW TO 34W4-1-5 and check observance of all shop safety, good housekeeping and fire prevention measures.
2. Instructor will administer appraisal test. Each student will answer questions with 75% accuracy, identifying the purpose, types and mechanical properties of hard surfacing materials.

CONCLUSION

SUMMARY:

1. Purpose, types and mechanical properties of hard surfacing materials.
2. Job requirements.
3. Types of hard facing alloys.
4. Preparation of metal for hard surfacing.
5. Hard surfacing carbon steel.
6. Finishing and grinding hard surface deposits.

CTT ASSIGNMENT: Read 3ABR53230-SG-301 Metallic Arc Welding and answer questions.

REMOTIVATION:

CLOSURE:

PREPARE THE MAN

Technical Training

Metals Processing Specialist

INTRODUCTION TO OXYACETYLENE WELDING

15 December 1972

13-5

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR53230-SG-101 through 106, 8 September 1971.
OPR: TWS
DISTRIBUTION: X
TWS - 200; TTOC - 2

Designed For ATC Course Use

DO NOT USE ON THE JOB

Metallurgy Branch
Chanute AFB, Illinois

SHOP AND FLIGHT LINE SAFETY PRACTICES

OBJECTIVES

After completing this study guide and your classroom instruction, you will be able to apply safety precautions in the shop, with radioactive parts and materials, on the flight line, and you will be able to utilize health and safety devices.

INTRODUCTION

Personal safety and fire prevention are especially important in metals processing because of the types of equipment which are used. The use of gas welding and arc welding equipment involves working with open flames and exposed electric arcs. In heat-treating there is danger of injury from the electric furnace or from hot metal. Electroplating involves the use of acids which can inflict bodily injury. Weld repair of fuel tanks, if proper precautions are not observed, can expose the worker to explosive or toxic gases. We will discuss specific safety and fire precautions relating to the various items of equipment and metals processing operations as we come to them in the course. In this study guide we mention briefly general precautions which must be observed with regard to shop safety, health and safety equipment, the flight line, and radioactivity.

INFORMATION

SHOP SAFETY

These general shop safety rules should be strictly enforced:

1. Keep oily or greasy rags in covered metal containers.

Study Guides and Workbooks are training publications authorized by Air Training Command (ATC) for student use in ATC courses.

The STUDY GUIDE (SG) presents the information you need to complete the unit of instruction or makes assignments for you to read in other publications which contain the required information.

The WORKBOOK (WB) contains work procedures designed to help you achieve the learning objectives of the unit of instruction. Knowledge acquired from using the study guide will help you perform the missions or exercises, solve the problems, or answer questions presented in the workbook.

The STUDY GUIDE AND WORKBOOK (SW) contains both SG and WB material under one cover. The two training publications may be combined when the WB is not designed for you to write in, or when both SG and WB are issued for you to keep.

Training publications are designed for ATC use only. They are updated as necessary for training purposes, but are NOT to be used on the job as authoritative references in preference to Technical Orders or other official publications.

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MODIFICATIONS

Pages 1-15 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

2. Wipe up oil or grease spots from the floor and the workbench immediately.

3. Do not weld in the vicinity of flammable materials.

4. Make certain that a fire extinguisher is near before you begin welding.

5. Do not allow hoses or arc welding leads to clutter the area and become stumbling hazards.

6. Keep all handtools and special tools not in use in their proper places.

7. Store metals in a stock rack.

8. Keep the shop area clean, well lighted, and well ventilated.

Health and Safety Equipment

Observe these health and safety equipment rules:

1. Do not wear ragged clothing, or clothing with open pockets, missing buttons, or rolled cuffs.

2. Do not wear low-cut shoes.

3. Wear approved helmet lenses, gloves, and apron for protection against infrared and ultra-violet rays when arc-welding.

4. Warn all persons near electric welding operations against looking at the arc.

5. Wear the type of goggles appropriate for the type of welding being performed. Wear goggles while you are using a cutting torch.

6. Wear chipping goggles to protect against flying hot slag when you are cleaning welds.

7. Mark hot metal. Do not leave hot metal in places where it will create a hazard.

8. Do not hold hot, welded material with tongs, rags, or with gloves which you use for buffing and grinding.

9. Cool all welds prior to buffing, grinding, or inspecting.

10. When you are electric-welding outside the stationary booth, inclose the arc with a portable screen to protect personnel.

11. Spilled cutting lubricant must be promptly mopped up to avoid the danger of slipping or falling.

DRILL PRESS

The following precautions apply to drill presses:

1. To prevent the work from slipping in the hand during drilling or boring, clamp the stock to the table of the machine.

2. If the stock becomes loose from a clam or vise during drilling or boring, stop the machine. Never try to stop spinning stock by hand.

3. Chuck wrenches must not be left in the chuck while the machine is in operation.

4. The operator of a drill press should not wear gloves, loose unbuttoned cuffs, long flowing ties, or jewelry.

5. Never attempt to use a rag to brush shavings or surplus oil from stock being drilled.

FIRE PREVENTION

Equally as important as good housekeeping is an efficient fire prevention system. You should carry out all safety precautions that pertain to the prevention of fires. You must know what to do when a fire occurs. Many fires are caused by carelessness and by poor housekeeping. Oily rags are fire hazards. Poor storage practices, especially of flammable materials, may cause fires. Overloaded electrical outlets and defective circuit breakers are also fire hazards. Here are a few precautions that you should observe; you can add to the list from your own experience.

1. Do not allow oily rags to accumulate.

2. Observe the signs in the NO SMOKING areas.

3. Do not allow your clothing to become saturated with fuel or oil. If they do, change your clothing as soon as possible.

4. Do not store gasoline, kerosene, jet fuel, or any other flammable fuels in open containers.

5. Make sure always that the static lines are in place and that the aircraft is grounded properly before you work on it.

6. Do not put cigarettes or matches in a waste basket even if they appear to be out.

7. Do not open any oxygen valve near a flame or a lighted cigarette.

Since fires will occur, no matter how many precautions are taken, you must be ready to fight them quickly and effectively. You should know the telephone number of the base fire department, the location of the fire extinguishers, and which type of extinguisher to use for the type of fire you are fighting. The telephone number of the base fire department is usually posted in large letters on posters in the shop, in the barracks, and on the flight line. As a rule, the base telephone directory has this number printed in large letters on the cover page or on one of the first pages of the book. If alarm boxes are installed on your base, learn where they are and how to use them. Locate the fire extinguisher in your work area, determine what type it is, and learn how to use it if the need arises.

WELDING AND CUTTING SAFETY

Because of the potential fire and explosion hazards present in any welding or flame cutting operation, safety rules must be followed very closely to avoid injury to personnel or damage to equipment.

1. No welding should be done on containers having had combustible materials in them until the containers have been properly flushed and steamed.

2. Tanks removed from aircraft for flushing and steaming must be electrically grounded during the operation.

3. Welding on aircraft is to be done only in the case of emergency and by special permission of an officer or supervisor charged with the responsibility for welding and flame cutting operations.

4. When welding is performed outside of certain designated safe areas, permission must be secured from an officer or supervisor having jurisdiction and special precautions must be taken against fires.

5. Hot metal should be cooled or marked HOT.

6. Hoses and arc welding leads should not be allowed to clutter stairs, walkways, or ladders to create a stumbling hazard.

7. A fire extinguisher must be in the immediate vicinity when welding is to be done. One or more fire extinguishers should be carried as regular equipment on all portable welding apparatus.

8. If welding must be done within 100 feet of tanks containing flammable liquids or vapors, no one shall be allowed to work on the tank or remain closer to the tank than the welder.

Storage and Handling of Cylinders

1. Oxygen and acetylene cylinders should be stored separately in a cool, well ventilated, fireproof building.

2. Explosion-proof electrical equipment must be used in cylinder storage rooms.

3. No open flames, grinding tools, or spark-emitting devices should be used within the storage rooms.

4. Smoking or carrying matches must not be allowed in the storage room.

5. Cylinders should be stored in an upright position while in storage.

6. Cylinders must not be stored near combustible material.

7. Cylinder valves should be closed tightly and protector caps should be in place.

8. Cylinders should be used in the order received and marked "MT" when empty.

9. Cylinders should be handled with more than ordinary caution. Rough handling may cause leaks that may result in an explosion.

10. Cylinder valves or plugs are not reparable. Leaking cylinders must be removed into the open, away from fire.

11. Valve protection caps should not be used for lifting cylinders. Cradles should be used for moving cylinders with a crane.

12. Welders must know the markings for cylinders according to the gas contained.

13. Acetylene gas must not be transferred from one cylinder to another or mixed with other gases under any circumstances.

14. Neither acetylene nor oxygen are used to test for leaks in any container.

15. Oil and oxygen under pressure may form a self-explosive mixture; therefore, no oil, gases, or lubricant of any kind should be used on oxygen cylinders or regulator connections.

16. Cylinders should not be used as rollers or for the support of materials.

17. If cylinder valves must be thawed out, only steam or hot water may be used.

FLIGHT LINE SAFETY

Observe the following flight line safety precautions:

1. Whenever possible, remove units from the aircraft and weld repair them in the shop.

2. Weld on aircraft only in case of emergency and then only by special permission of the supervisor in charge of the aircraft.

3. When welding must be performed anywhere on the flight line outside of designated safe areas, secure permission from the officer in charge of the area.

4. Remove all flammable materials from the area prior to welding.

5. Insure that suitable fire extinguishers are in place prior to welding.

6. Insure that explosive hazards do not exist prior to welding.

7. If a fire hazard exists after all precautionary measures have been taken, the fire warden will decide whether welding will be performed.

RADIOACTIVITY

Radioactivity is not normally a health hazard in metals processing, especially since nondestructive inspection has become a separate Air Force specialty. You may never be required to work near radioactive or radioactive-contaminated materials; however, radiation is such a serious health hazard, that elaborate precautions are taken in the Air Force to guard against even accidental exposure. You cannot see radioactivity, and several hours may elapse after exposure before you feel any effects; therefore, you must be able to instantly recognize radiation warnings.

There are three types of radiation: alpha, beta, and gamma. A single particle of radioactive material may emit all three types of radiation. Alpha and beta radiation have very little penetrating power. Alpha radiation penetrates only a few inches of air and beta radiation penetrates only a few feet of air. External contact is not harmful. Alpha radiation is harmful only if you breathe, eat, or drink contaminated particles, or if they come in contact with a broken skin surface. Exposure to beta radiation is more hazardous than alpha radiation because of its greater penetrating power. You can protect against it by wearing a respirator and protective clothing. Gamma radiation penetrates many hundreds of feet of air; there is no barrier which can completely stop its penetration. External contact is extremely hazardous and can result in cell damage either externally or internally. The primary purpose of the various AFTO Form 9 warning signs is to guard against gamma radiation.

All radiation signs display the distinctive magenta insignia against a yellow background with black block type as shown in figure 1. The warning signs are designed to attract immediate attention. Each sign is designed for a specific purpose, and the exact size for most of them is specified by technical order. The AFTO 9 series forms are listed below.

1. AFTO Form 9, Radiation Area Warning Placard (8 1/2 x 11 inches). These placards are posted in conspicuous places and indicate that the radiation intensity in the area exceeds a safe level.

2. AFTO Form 9A, figure 1, Radiation Warning Tag (3 1/2 x 6 1/4 inches). This tag identifies radioactive parts, equipment, or material. It is attached to each item.

3. AFTO Form 9B, Radiation Warning Label. This is a flexible but durable gummed label. A sufficient number of labels are attached to insure that one is visible from any direction of approach.

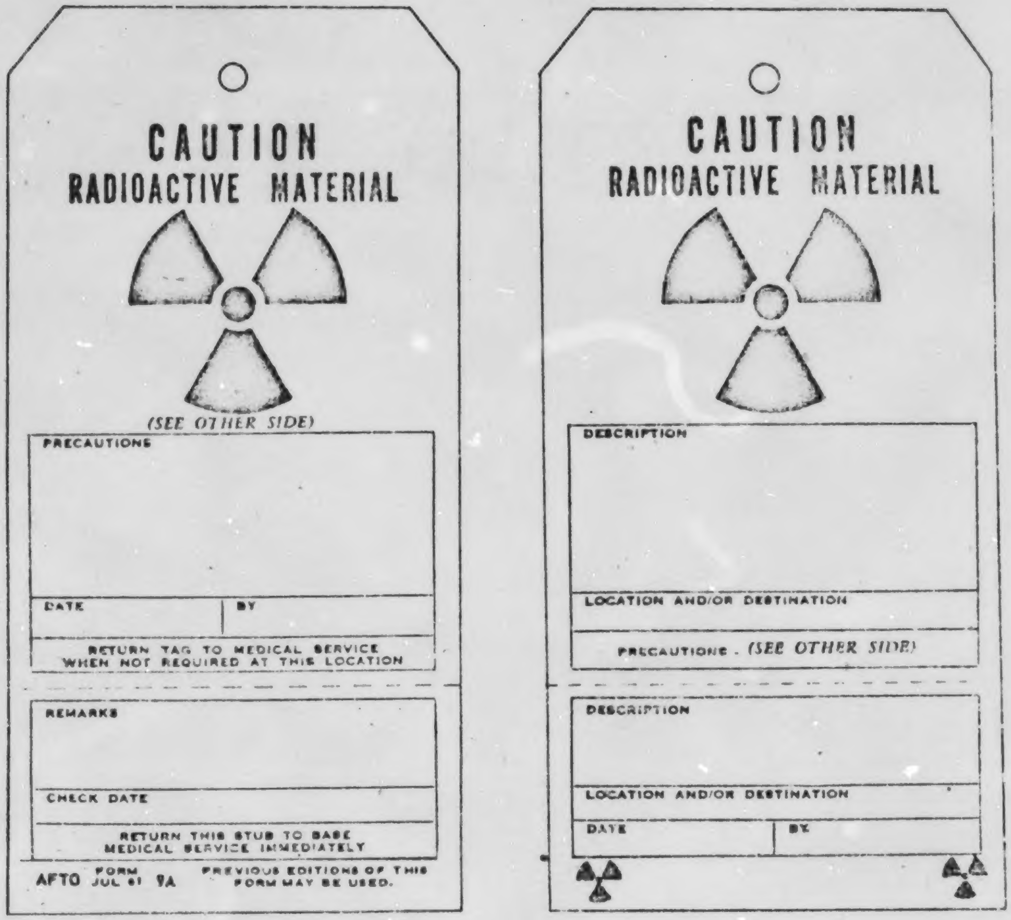
4. AFTO Form 9C, Radioactive Material Warning Placard (8 1/2 x 11 inches). This placard identifies an area in which radioactive materials are stored.

5. AFTO Form 9D, Ingestion Hazard Placard (8 1/2 x 11 inches). This placard warns against eating, drinking, or smoking in the area and is displayed as directed by the base medical service.

6. AFTO Form 9E, High Radiation Warning Placard (18 x 24 inches). This placard identifies an area in which the radiation intensity exceeds 100 mr/hr.

7. AFTO Form 9F, Airborne Radioactivity Warning Placard. The use of this placard is directed by the base medical service when radioactivity is present.

Prior to working near radioactive or radioactive-contaminated materials, metals processing people, and in particular the shop foreman, should become familiar with the 00-110 technical order series. This series provides useful information about safety precautions, decontamination procedures, and radioactive waste disposal. For more details about marking and identification of radioactive and radioactive contaminated materials, consult TO 00-110N-3, _Requisition, Handling, Storing, and Identification of Radioactive and Radioactively Contaminated Material_.



CAUTION
RADIOACTIVE MATERIAL

(SEE OTHER SIDE)

PRECAUTIONS

DATE | BY

RETURN TAG TO MEDICAL SERVICE
WHEN NOT REQUIRED AT THIS LOCATION

REMARKS

CHECK DATE

RETURN THIS STUB TO BASE
MEDICAL SERVICE IMMEDIATELY

AFTO FORM JUL 61 9A PREVIOUS EDITIONS OF THIS FORM MAY BE USED.

CAUTION
RADIOACTIVE MATERIAL

DESCRIPTION

LOCATION AND/OR DESTINATION

PRECAUTIONS - (SEE OTHER SIDE)

DESCRIPTION

LOCATION AND/OR DESTINATION

DATE | BY

Figure 1. Radiation Tag.

Metallurgy Branch
Chanute AFB, Illinois

3ABR53230-SG-105

HANDTOOLS

OBJECTIVES

After completing this study guide and your classroom instruction, you will be able to select, properly use, and care for handtools; store shop equipment and materials.

INTRODUCTION

Each tool and measuring device is designed to do a specific job in a specific way. Although some of them can be used for more than one purpose, you can do a better job by using them for their intended purpose. By learning to properly use them, you can improve the quality of your work.

INFORMATION

HANDTOOLS

The process of laying out bench metal work projects and the subsequent shaping, forming or manufacturing of these projects require a good knowledge of the tools which are used to do the job. We will explain these tools in more detail so that you may acquire some of the techniques and tricks-of-the-trade that otherwise might escape you and prevent you from developing skill in their use.

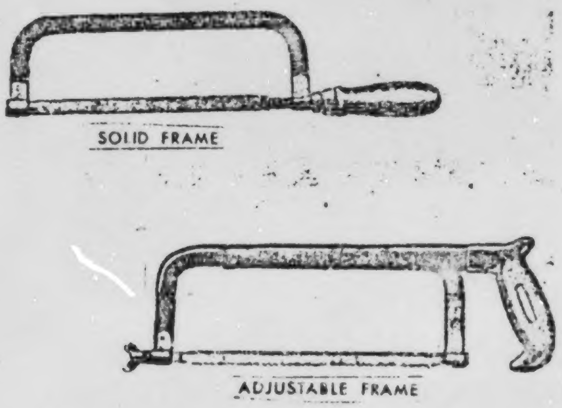


Figure 2. Hacksaws.

HACKSAW

Frame

A hacksaw is used to cut metal much as a carpenter's saw is used to cut wood. Common hand hacksaws have either adjustable frames or solid frames as shown in figure 2. Hacksaw blades of various types are inserted in the frame for different kinds of work. An adjustable frame can be adjusted to hold blades from 8 to 16 inches long. A solid frame, although more rigid, takes only the length of blade for which it is made. This length is the distance between the two pins which hold the blades in place. All hacksaw frames hold the blades either parallel or at right angles to the frame and are provided with screws for pulling them taut.

Blades

Hacksaw blades are made of high-grade tool steel, hardened and tempered. There are two types: the all hard and the flexible. All hard blades are hardened throughout, while only the teeth of the flexible blades are hardened. All blades are from 7/16 to 9/16 inch wide, with 14 to 32 teeth per inch, and are 8 to 16 inches long. Each blade has a hole at each end which hooks to pins on the frame.

The teeth of all hacksaw blades are set to provide clearance for the blade. The three different kinds of set are alternate, raker, and undulated, as shown in figure 3. Alternate set means that alternate teeth are bent slightly sidewise in opposite directions. On a raker set blade, every third tooth remains straight, and the other two are set alternately. On an undulated set blade, short sections of teeth are bent in opposite directions. A blade should have just enough set to produce a free, smooth, rapid cut, which makers a kerf slightly wider than the blade itself, and removes no more stock than necessary.

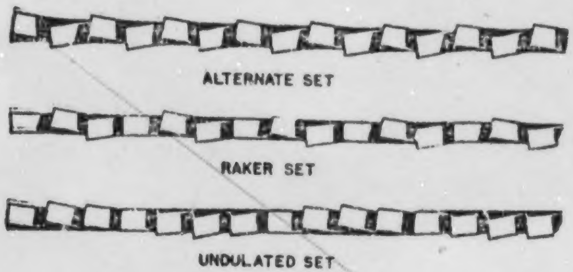


Figure 3. Set of Hacksaw Blade Teeth.

Selecting the best hacksaw blade for a specific job is a question of using either an all-hard or flexible blade with a pitch test suited to the work at hand. Several factors should be considered in blade selection.

1. An all hard blade is best for sawing brass, tool steel, cast iron, rails, and other stock of heavy cross section.

2. In general, a flexible blade is used for sawing hollow shapes and metals of light cross section, such as channel iron, tubing, tin, copper, aluminum, or babbit.

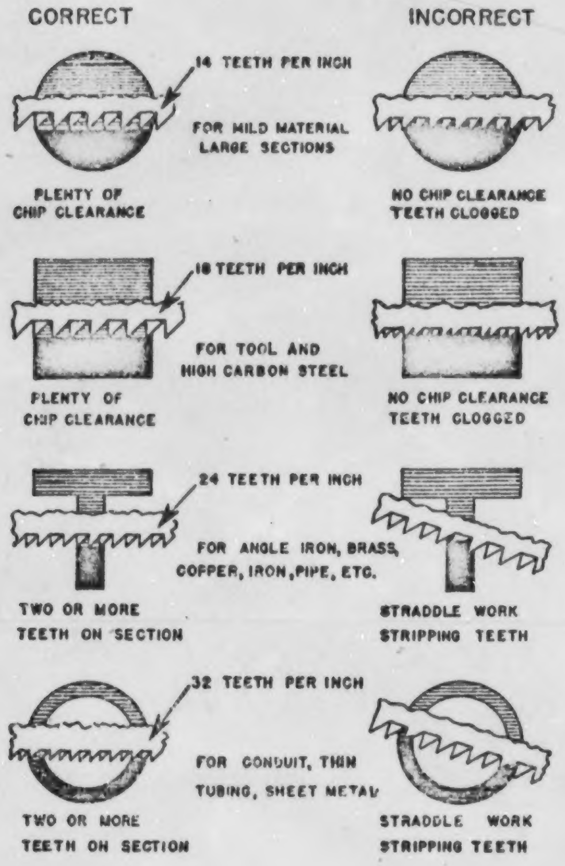

CORRECT
INCORRECT
14 TEETH PER INCH
FOR MILD MATERIAL LARGE SECTIONS
PLENTY OF CHIP CLEARANCE
NO CHIP CLEARANCE TEETH CLOGGED
18 TEETH PER INCH
FOR TOOL AND HIGH CARBON STEEL
PLENTY OF CHIP CLEARANCE
NO CHIP CLEARANCE TEETH CLOGGED
24 TEETH PER INCH
FOR ANGLE IRON, BRASS, COPPER, IRON, PIPE, ETC.
TWO OR MORE TEETH ON SECTION
STRADDLE WORK STRIPPING TEETH
32 TEETH PER INCH
FOR CONDUIT, THIN TUBING, SHEET METAL
TWO OR MORE TEETH ON SECTION
STRADDLE WORK STRIPPING TEETH

Figure 4. Correct Pitch of Hacksaw Blades.

3. Figure 4 illustrates the principles involved in selecting blades with the most suitable pitch for most jobs.

a. Use a blade with 14 teeth per inch on machine steel, cold-rolled steel, or structural steel. This course pitch makes the saw free and fast cutting.

b. Use a blade with 18 teeth per inch on solid stock, aluminum, babbit, tool steel, high-speed steel, or cast iron. This pitch is recommended for general use.

c. Use a blade with 24 teeth per inch on tubing, tin, brass, copper, channel iron, and sheet metal over 18 gage. If a courser pitch is used, thin stock tends to strip the teeth out of the blades. Two or more teeth should be in contact with the work, as shown in figure 4.

d. Use a blade with 32 teeth per inch on thin-walled tubing and conduit, and on sheet metal thinner than 18 gage.

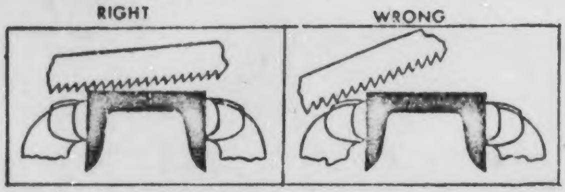


Figure 5. Starting Hacksaw Cuts.

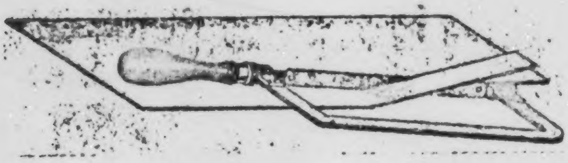


Figure 6. Making Cut Deeper Than Frame.

After selecting the correct blade and insuring that it is stretched tightly in the frame, mark the stock at the point to be cut with a scriber, soapstone, or pencil. If special accuracy is required, nick the work with a file and start the saw in the nick. Be certain that the work is gripped tightly in a vise, with the line to be cut as close to the vise jaws as possible. To cut angle iron or any odd-shaped work, expose as much of the surface as possible so that a corner may be cut gradually and the maximum number of teeth engaged throughout the cut. It is best to start cutting on the widest surface of the work. Figure 5 shows the right and wrong methods of starting hacksaw cuts. The hacksaw should be held vertically and moved forward with a light steady stroke. At the end of the stroke, relieve the pressure and draw the blade straight back. After the first few strokes, make each stroke as long as possible without striking the saw frame against the work. Do not bear down on the saw on the return stroke. Keep the saw in the same plane through the cut, otherwise the blade may be cramped and broken. To make a cut deeper than the frame, turn the blade sidewise, as shown in figure 6. The most effective cutting speed is from 50 to 60 strokes per minute. When the work is nearly cut through, relieve the pressure on the saw slightly to prevent the teeth from catching. Special care is needed toward the end of a cut through thin material. To cut very thin stock, it is advisable to clamp the work between two pieces of wood or soft metal and saw through all three pieces. This prevents chattering and possible damage to the work.

The chief danger in using hacksaws is injury to the hand when a blade breaks. The blade may break if you bear down too hard on the cut or do not push the saw in a straight line. If the work is not tight in the vise, it can sometimes slip, twisting the blade enough to break it.

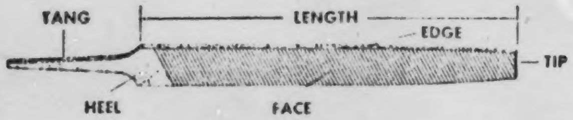

TANG
LENGTH
EDGE
TIP
HEEL
FACE

Figure 7. File Nomenclature.

FILES

A file is a hardened high-carbon steel tool for cutting, removing, smoothing, or polishing metal. The cutting teeth are made by diagonal rows of chisel cuts along the face of the file, as shown in figure 7.

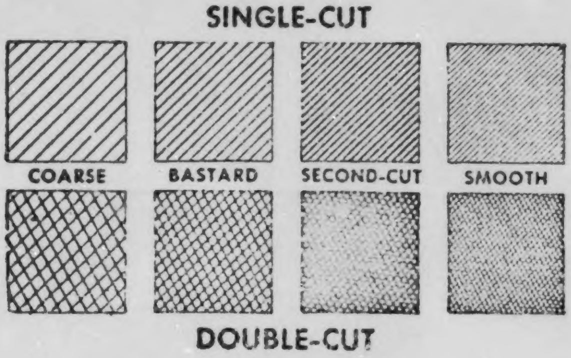

SINGLE-CUT
COARSE
BASTARD
SECOND-CUT
SMOOTH
DOUBLE-CUT

Figure 8. File Cuts.

Files are classified by name, grade, and cut. The cut may be either single or double, as shown in figure 8. The grade refers to the distance between parallel cuts and may be listed in the order of coarseness as float, corase, bastard, second cut, smooth, or dead smooth, as shown in figure 8.

Files are made in various shapes and range in length from 3 to 24 inches. Figure 9 shows a cross sectional view of the various file shapes.

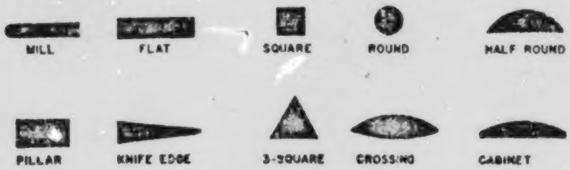

MILL
FLAT
SQUARE
ROUND
HALF ROUND
PILLAR
KNIFE EDGE
3-SQUARE
CROSSING
CABINET

Figure 9. Shapes of Files

Mill File

The mill file is a single cut file tapering in thickness and width for one third of its length. It is useful for fine work. This file is available with either square or round edges or with a safe edge which is smooth and has no cutting teeth.

Flat File

This is a double cut file tapering in thickness and width; it is used mainly as a fast cutting tool.

Round File

The round file is usually tapered and has a single cut. It may be double cut in larger sizes. It is also known as a rat tail file. Parallel or untapered round files are also available. The main use of this type of file is to enlarge circular openings or concave surfaces.

Hand File

This is a single cut file, similar in shape to a flat file with parallel sides and a slight taper in thickness. It has square edges, one of which has a safe edge.

Half Round File

This is a double-cut file, tapering in thickness and width, with one flat side and one oval side. This file is used for removing stock rapidly and for filing concave surfaces.

Selecting the Correct File

1. For heavy, rough cutting, use a large, coarse, double-cut file.

2. For finishing cuts, use a second-cut or smooth, single-cut file.

3. For filing cast iron, start with a bastard cut and finish with a second-cut file.

4. For filing soft steel, start with a second-cut, and finish with a smooth file.

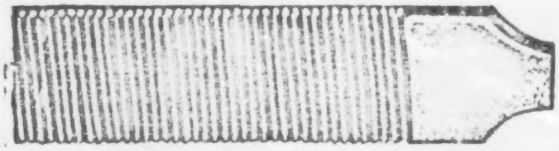


Figure 10. Float-Cut File.

5. For filing hard steel, start with a smooth-cut, and finish with a dead smooth file.

6. For filing aluminum, lead, or babbit metal, use a float cut file, as shown in figure 10.

7. For small work, use a short file; for a medium sized work, use an 8 or 10 inch file; for large work, use a file as large as you can conveniently control.

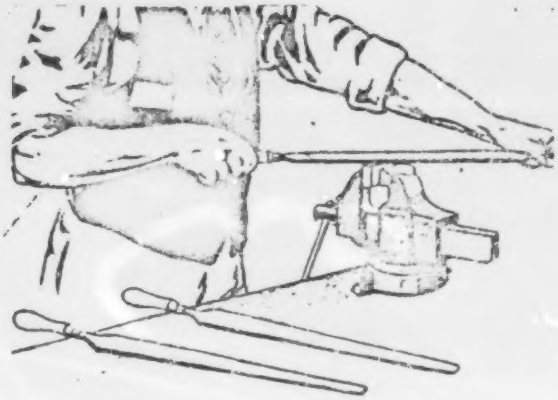


Figure 11. Correct Way to Hold File.

Using a File

The correct way to hold a file is with the handle against the palm of the right hand, thumb on top, and the end of the file in the left hand with the fingers curled under it, as shown in figure 11. In filing, lean forward with the weight evenly distributed on both feet. The file must be held straight or the surface of the work becomes uneven. Too much speed may ruin the file and the work, so do not take more than 30 to 40 strokes per minute. Apply pressure on the forward stroke only. Lift the file from the work on the return stroke to prevent it from becoming dulled by the scraping action. Apply only enough pressure to make the file cut evenly. On soft metals, such as aluminum or lead, pressure on the return stroke helps to keep the cuts in the file clean of metal. When round surfaces are filed, best results are obtained by working as shown in figure 12. This is a rocking motion.

It is bad practice to bear down hard on a new file. When the file is new, the teeth are very fine and cannot stand much pressure.

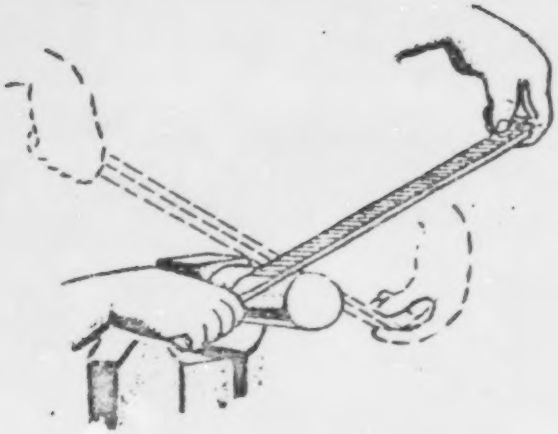


Figure 12. Filing Round Surfaces.

Hold the work firmly in a vise, with the surface to be filed projecting slightly above the vise jaws, and parallel with them, as shown in figure 11. If the work is not firm in the vise, the file may chatter and damage the teeth.

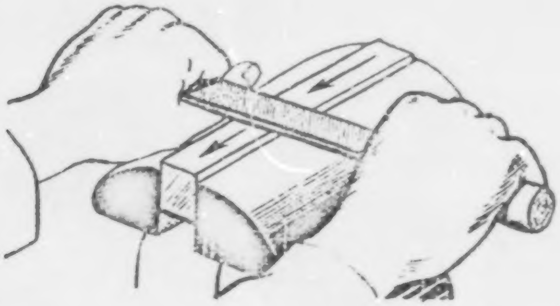


Figure 13. Draw-Filing.

To produce a very smooth surface, work is sometimes draw filed. In draw filing, move the file sidewise along the work, as shown in figure 13. A single-cut smooth file should be used. Pressure is heaviest on the stroke toward the body and very light on the return stroke. For a finished smooth surface, wrap a piece of fine emery cloth around the file and proceed as in draw filing.

A file should never be used without a handle, since the tang may jab into your hand. Be certain that the handle is held firmly on the tang of the file. Small files, such as needle and ignition files, have integral handles.

File Care

PINNING. In the filing of soft metals, narrow surfaces, or corners, small particles of metal are likely to clog the teeth of the file and scratch the material being filed. This is called pinning. Pinning is usually the result of putting too much pressure on the file, especially when it is a new one. To avoid pinning, be certain that the file is broken in before taking heavy cuts. Rubbing chalk on a file before using it helps to prevent pinning.

BREAKING IN. A new file should be broken in by using it first on brass, bronze, or smooth cast iron. A new file should not be broken in on a narrow surface, such as sheet iron, because the narrow edge is likely to break off the sharp points of the teeth. A new file should never be used to remove the fins or the scale on cast iron. Most of the damage to new files is caused by using too much pressure during the first few strokes.

A file should never be used on material harder than itself or on sandy or scaly castings. One stroke across such a sand or scale makes the file useless. To prevent scratching in filing wrought iron, steel, or hard fiber, apply a little oil to the surface of the file to lubricate the chip.

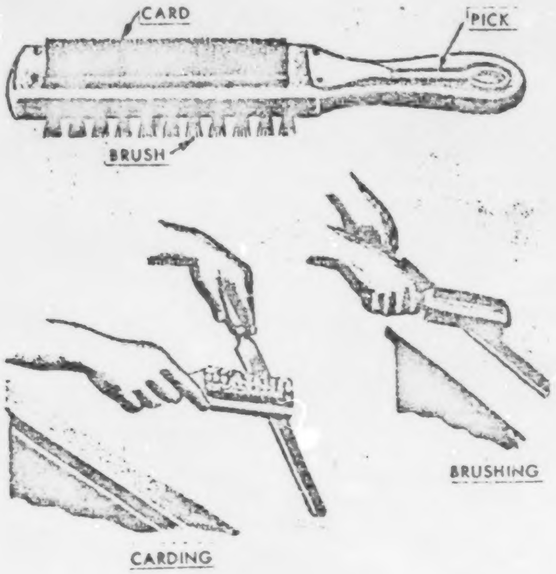


Figure 14. Cleaning a File.

CLEANING. If a file is pinning or not cutting properly, it should be cleaned with a file card, pick, and brush, as shown in figure 14. The pick is a small pointed wire instrument often furnished with a file card for cleaning out individual cuts in the file clogged too tightly with metal to clean with a file card. To clean a file, lay it flat on the bench and draw the file card and brush back and forth across it parallel with the cuts.

HANDLING. Like any cutting tool, a file is easily dulled by rough or improper handling. Files should not be thrown into a drawer or box where they can rub against each other or against other tools. It is best to store them in separate holders, such as clips, straps, or holes cut in a wooden block. Too rapid strokes or failure to lift the file off the work on the return stroke quickly spoils its cutting efficiency. For best results and long file life, use the file card and brush often.

Safety Precautions

1. Never use a file without a firmly attached handle, particularly in filing work rotating on a lathe.

2. Do not salvage a small rat-tailed file for the purpose of using it as a prick punch.

3. Never use a file as a pry. It may break and throw off tiny bits of steel which may fly into your eyes.

4. Never use a file as a hammer, as this not only damages the file but may throw steel particles into your eyes.

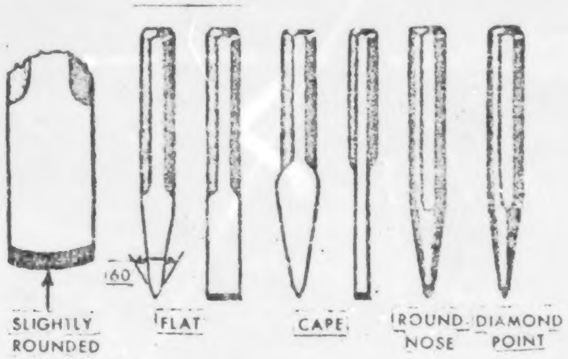


Figure 15. Commonly Used Cold Chisels Correctly Sharpened.

CHISELS

Cold chisels are tools used for chipping or cutting cold metal by hand prior to filing. They are made of a good grade of tool steel, hardened at the point, and sharpened to a cutting edge at one end. They are classified according to the shape of the point, the most common shapes being flat, cape, roundnose, and diamond-point, figure 15.

Best results can be obtained if the type of cold chisel is selected for the particular work to be done.

1. Use a flat chisel for cutting sheet metal or for chipping flat surfaces.

2. Use a cape chisel for cutting grooves, slots, or keyways, or for chipping flat surfaces when a flat chisel would be too wide.

3. Use a roundnose chisel for cutting round (concave) grooves and for drawing back drills which have "run out."

4. Use a diamond-point chisel for cutting V-shaped grooves.

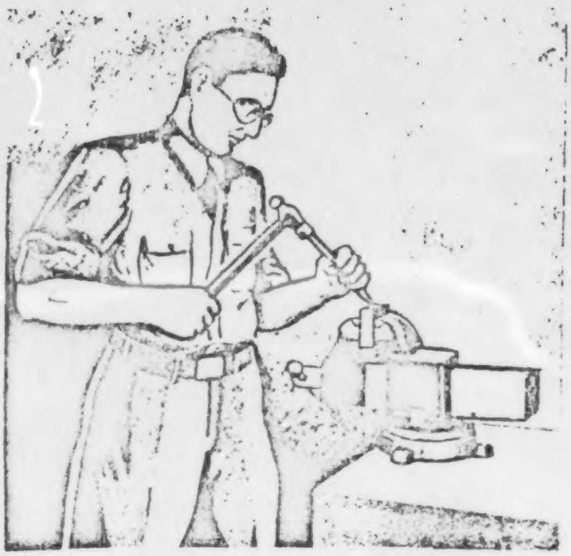


Figure 16. Correct Use of Cold Chisel.

Using Cold Chisels

As a rule, the cold chisel is used for cutting wire or small round stock or for cutting sheet metal or plate. Figure 16 shows the correct way to hold the hammer and chisel and the best position for the work. The cutting edge of the chisel should be placed at the point where the cut is desired, at the angle which will cause it to follow the desired finished surface. After each blow of the hammer, set the chisel to the correct position for the next cut. The depth of the cut depends on the angle at which the chisel is held in relation to the work. The sharper this angle, the deeper the cut. It is best to watch the edge, and not the head of the chisel. Sharp, quick blows should be struck, taking care that the hammer does not slip off the chisel and injure your hand.

To cut wire or round stock, the following procedure should be used:

1. Mark the point at which the cut is to be made with chalk or colored pencil.

2. Place the work on the chipping block of an anvil or on any soft metal support.

3. Hold the chisel with the cutting edge on the chalk or pencil mark and the body of the chisel in a vertical position.

4. Strike the chisel a light blow with the hammer, and examine the chisel mark on the work to make certain the cut is at the desired point.

5. Drive the chisel into the work with vigorous blows. The last stroke or two should be made lightly to avoid unnecessary damage to the supporting surface.

6. Heavier work can be cut in much the same way except that the cut is made about halfway through the stock from one side, the work turned over, and the cut finished from the opposite side.

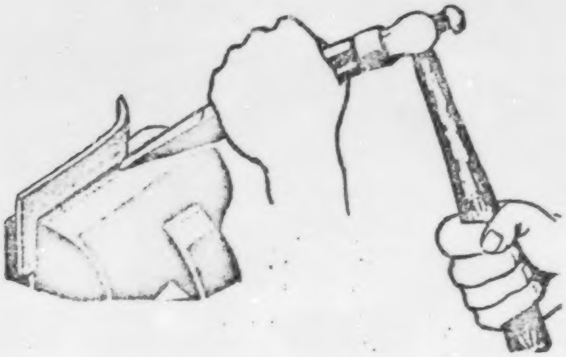


Figure 17. Cutting Sheet Metal With Cold Chisel.

Cutting sheet or plate metal with a cold chisel should be avoided as much as possible since stretching of the metal invariably results. However, when there is no alternative, the best procedure is as follows:

1. Draw a straight line on the work with a scriber where the cut is to be made.

2. Grip the work firmly in a vise with the scribed line even with or just below the tip of the vise jaws, with the waste metal extending above the jaws, as shown in figure 17.

3. Use a sharp chisel and start at the edge of the work and cut along the scribed line, using the jaws of the vise as a base for securing a shearing action. Hold the chisel firmly against the work and strike it vigorously. Be sure to keep the cutting edge of the chisel flat against the vise jaws, as shown in figure 17.

To chip steel, it is advisable to lubricate the chisel point with a light machine oil. This makes the chisel easier to drive and causes it to cut faster than it would if it were dry. To chip cast iron, chip from the edges of the work toward the center to avoid breaking off the corners.

Care of Cold Chisels

SHARPENING. Chisels, like all cutting tools, must be sharp to give satisfactory service. The cutting angle should be about 60 degrees and the edge slightly rounded, as shown in figure 15. Sharpening is usually done on an ordinary coarse grinding wheel. The chisel should not be pressed too hard against the wheel, or enough heat may be generated to remove some of the hardness from the steel. If the cutting angle is ground too small, the chisel is not safe to

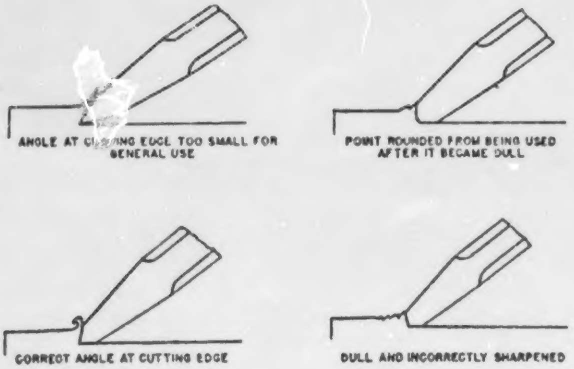

ANGLE AT CUTTING EDGE TOO SMALL FOR GENERAL USE
POINT ROUNDED FROM BEING USED AFTER IT BECAME DULL
CORRECT ANGLE AT CUTTING EDGE
DULL AND INCORRECTLY SHARPENED

Figure 18. Results of Correct and Incorrect Sharpening.

use. If the angle is much over 60 degrees, the tool cannot cut properly. Figure 18 shows the results of correct and incorrect sharpening.

MUSHROOM HEAD. The blows of the hammer eventually cause the blunt end of the chisel to spread out until it resembles a mushroom. When this happens, the end should be ground back to its original shape. It is dangerous to use a chisel with a mushroom head because pieces may fly off and cause injury.

Safety Precautions

The following precautions should be followed in using cold chisels, both for the worker's safety and to prevent damaging either the tool or the work.

1. A chipping guard should be placed in front of the work to guard against flying metal chips.

2. Always wear goggles.

3. Keep the hammer and the blunt end of the chisel free from grease or oil to prevent the hammer from slipping and bruising your hand.

4. If the fork is held in a vise, the jaws should have guards made of soft metal, such as copper or brass, to protect the finish of the work. Put a block under the work so that it cannot slip out of the vise. Always chip toward the solid jaw of the vise. If possible, avoid chipping parallel with the jaws.

RULES

Rules used by the welder are graduated measuring instruments usually made of metal. Ordinarily, the edges of a 12-inch rule are graduated in 8ths and 16ths on one side and in 32nds and 64ths on the other. Figure 19 shows the edges of a rule.

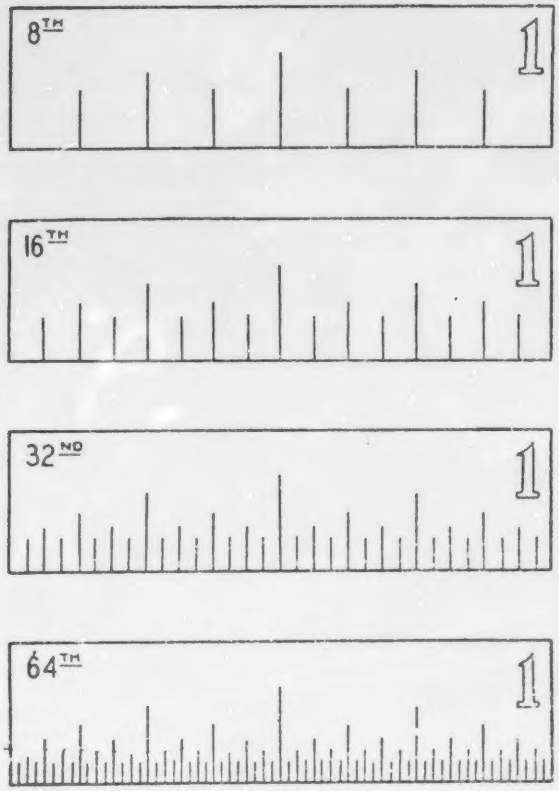


Figure 19. Four Edges of a 12" Rule.

If you can locate the labelled fractional values in 8ths, 16ths, 32nds, and 64ths, locating odd fractional values such as 51/64, is relatively simple. You first locate the nearest labelled fractional value on the 64th scale, which in this case is 48/64 inch and then count off three more minor graduations, 48/64 plus 3/64 equal 51/64 as shown in figure 20.

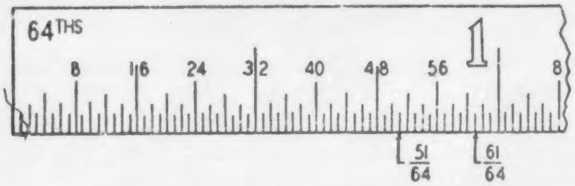


Figure 20. Locating Odd Fractional Values on 64th Scale.

Locating odd fractional values in 16ths and 32nds, as shown in figure 21, are done in the same manner as locating 64ths. In some cases it is easier to subtract minor graduations, especially when it is nearer to one of the larger labelled values.

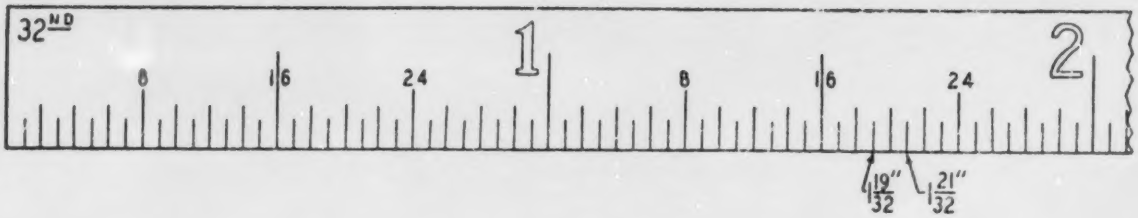

32ND
8
16
24
1
8
16
24
2
1 19/32"
1 21/32"

Figure 21. Locating of Odd Fractional Values on 32nd Scale.

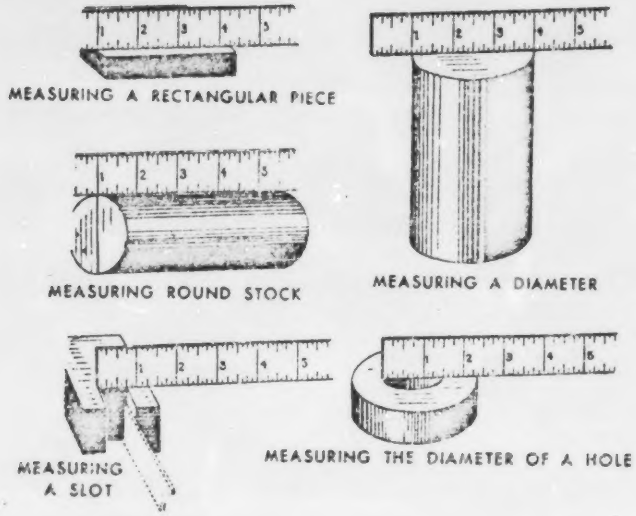

MEASURING A RECTANGULAR PIECE
MEASURING A DIAMETER
MEASURING ROUND STOCK
MEASURING A SLOT
MEASURING THE DIAMETER OF A HOLE

Figure 22. Application of a Steel Rule.

Figure 22 shows some of the applications of the steel rule. The rule should be cared for by wiping it with light machine oil and carefully storing the rule in a separate compartment of the tool box to protect it from rust, scratches, and other damage.

Figure 23. Scriber.

LAYOUT TOOLS

Scriber

Figure 23 shows a scriber which is used for marking lines on metal. It is generally used with a straight edge rule. Centers of holes can be located with it by drawing two intersecting lines according to specified dimensions and marking the intersection with a center punch. The bent end is used for marking the inside of

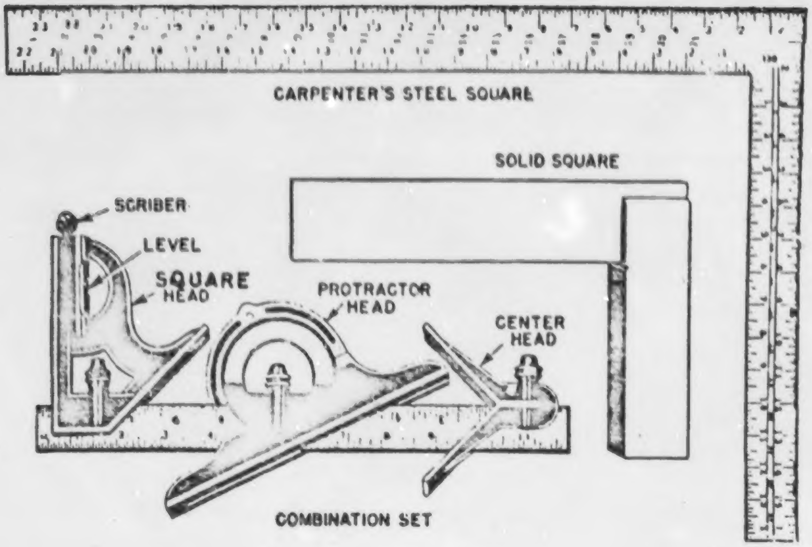


Figure 24. Combination Set and Squares.

cylindrical objects or partially closed recesses. Keep the scriber sharp, and in scribing lines, hold it firmly to the edge of the straight edge using only enough pressure to leave a clear mark with one stroke.

Squares

Squares are used for measuring and checking angles. Figure 24 shows the commonly used types. The solid square is convenient for checking right angles only. The carpenter's steel square is quite often used by the welder for layout jobs on large metal surfaces.

Combination Set

The combination set is used for shop layout work. You should become familiar with its numerous applications. The illustration of the combination set in figure 24 shows it equipped with a protractor head, square head, and centering head. Be certain that the blade and accessories of the combination set are kept clean. Apply small amounts of oil to the blade occasionally to prevent rusting. Figure 25 shows a number of applications of the square and center head. Figure 26 shows a common application of the protractor head in checking the angle of cut on a scarf tubular splice.

Figure 27 shows a center punch which is used for marking the center of holes and radii for laying out work and for making a conical depression in metal for starting twist drills. The size of the center punch is determined by the diameter of the base of the cone forming the point. The size of a center punch to use for any particular job is determined by the size of the drill to be used and also the purpose for which the center mark is made.

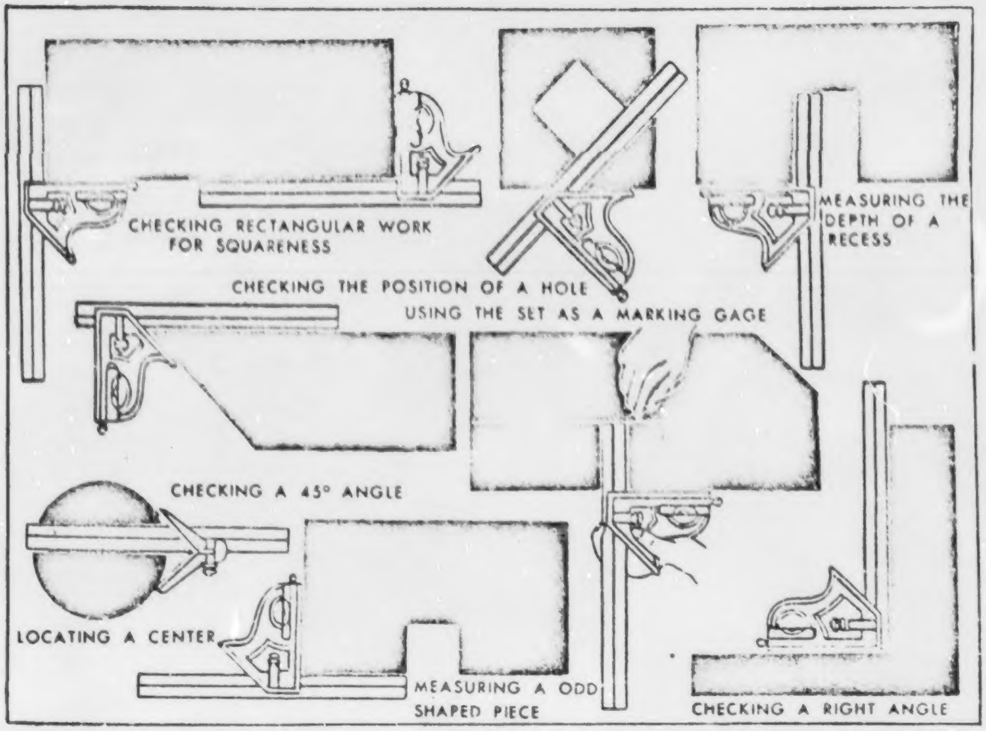

CHECKING RECTANGULAR WORK FOR SQUARENESS
CHECKING THE POSITION OF A HOLE
MEASURING THE DEPTH OF A RECESS
USING THE SET AS A MARKING GAGE
CHECKING A 45° ANGLE
LOCATING A CENTER
MEASURING A ODD SHAPED PIECE
CHECKING A RIGHT ANGLE

Figure 25. Applications of the Square Head and Center Head.

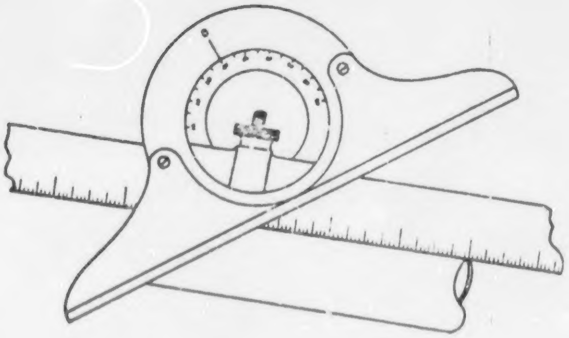


Figure 26. Application of the Protractor Head.

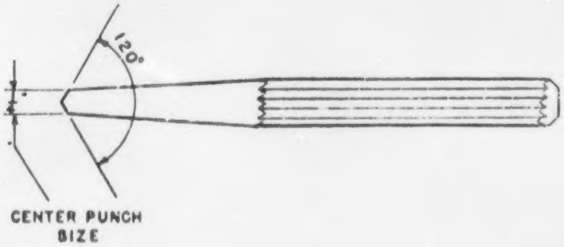

120°
CENTER PUNCH SIZE

Figure 27. Center Punch.

The included angle of the point of the center punch should be 120° to allow the 118° included angle of a standard ground drill to seat well into the bottom of the conical depression, as shown in figure 27. If, as sometimes happens, the first location is slightly off center, a correction can be made by tilting the punch and driving the point in the direction desired. When the error has been corrected, the punch should be brought to a vertical position and given a sharp rap to insure a perfect new location for the drill point.

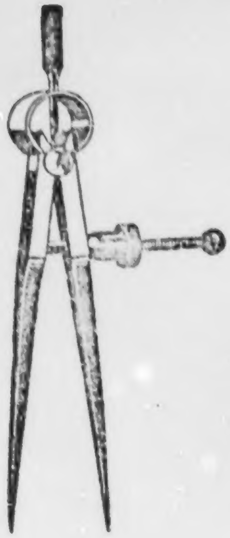


Figure 28. Dividers.

Dividers

Dividers are used for measuring distances between points, for transferring distances directly from a rule, or for scribing circles. Figure 28 shows a pair of dividers. Keep the points of the dividers sharp, and use only enough pressure on them to make a clear mark on the work.

Metallurgy Branch
Chanute AFB, Illinois

3ABR53230-SG-106

OPERATION AND MAINTENANCE OF WELDING EQUIPMENT

OBJECTIVES

After completing this study guide and your classroom instruction you will be able to assemble and operate oxyacetylene equipment, test apparatus for gas leaks; adjust torch for proper welding flames, disassemble welding apparatus; and perform operator maintenance on welding and cutting equipment.

INTRODUCTION

As a welder, you must be familiar with the correct procedure for the setup and operation of both stationary and portable oxyacetylene welding equipment. Air force shops make extensive use of portable welding equipment. In shops which have stationary equipment, the portable outfit is used for work which cannot be done in the shop. Basically, the equipment used for each is the same except that the gases are piped to the welding station in a stationary setup. The portable outfit is operated directly from cylinders of gases which are mounted on a cart or truck. Double stage (two gage) regulators must also be used on portable outfits. The welding outfit is your most important tool as a welder. You must be familiar with the proper care of the outfit and be able to maintain each unit of the welding setup.

INFORMATION

OPERATION AND ASSEMBLY OF OXYACETYLENE WELDING EQUIPMENT

An oxyacetylene welding outfit operates on oxygen and acetylene. The equipment consists of oxygen and acetylene regulators, two lengths of hose with fittings, and a welding torch together with a cutting attachment or a separate cutting torch. In addition, suitable goggles are required for eye protection, a spark igniter to light the torch, gloves to protect the hands, and wrenches for the various connections on the cylinders, regulators, and the torches.

The use of oxyacetylene welding equipment involves hazards which are specific to such equipment and others that relate to heating in general. The oxyacetylene flame and the sparks produced in welding and cutting can ignite combustible materials and can cause damaging fires. The precautions commonly observed to prevent fire in handling blow torches and other open flames, should be observed in handling oxyacetylene welding equipment. The specific hazards of the oxyacetylene process relate to the gases, oxygen and acetylene, their containers, and the apparatus used to control and combine them into a flame.

STATIONARY OXYACETYLENE WELDING OUTFIT

The stationary oxyacetylene welding equipment shown in figure 29, consists of a single stage regulator for oxygen and a single stage

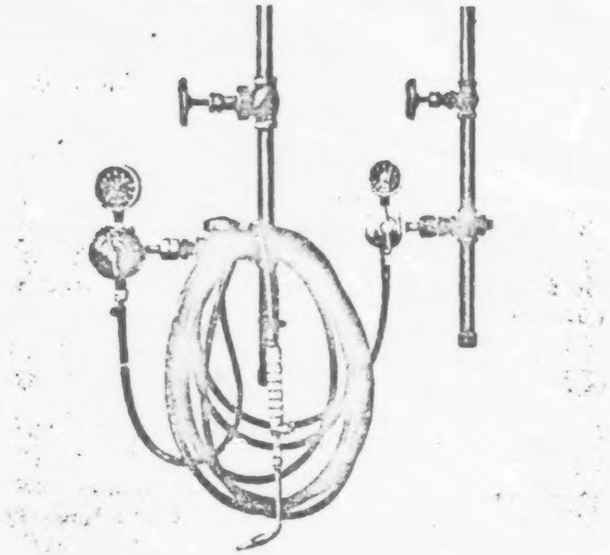


Figure 29. Stationary Welding Station and Equipment.

regulator for acetylene attached to the gas distributing pipe lines, a welding torch with a set of tips, 12 1/2 to 15 feet of acetylene and oxygen hose and fittings for attaching to the regulators and torch, apparatus wrench, torch igniter, and a pair of welding goggles.

Regulators

Regulators are either of the single-stage or two-stage type. Single-stage regulators reduce the pressure of the gases from cylinder or line pressure to working pressure in one stage. Two-stage regulators perform the same work in two stages. Since the pressure drop in each stage is less with a two-stage regulator, the pressure regulation is more accurate and less fluctuating. Although mechanical details of regulator construction vary among different manufacturers, the fundamental operating principles are the same. These same principles apply to both oxygen and acetylene regulators.

SINGLE-STAGE REGULATOR. Figure 30 shows the design of a typical single-stage regulator. The regulator mechanism consists of a nozzle through which the high-pressure gases pass, a valve seat to close off the nozzle, a diaphragm, and balancing springs. These are all inclosed in a suitable housing. Pressure gages are provided to indicate the pressure in the cylinder or pipe line (inlet) as well as the working pressure (outlet). The gage nearest the cylinder valve is the high-pressure gage used to record cylinder pressure. The outlet pressure gage is the low-pressure gage used to indicate the working pressure.

The oxygen enters the regulator through the high-pressure inlet connection and passes through a screen or filter which removes dust and dirt. The seat closing off the nozzle is not raised until the adjusting screw is turned in. When the adjusting screw is turned

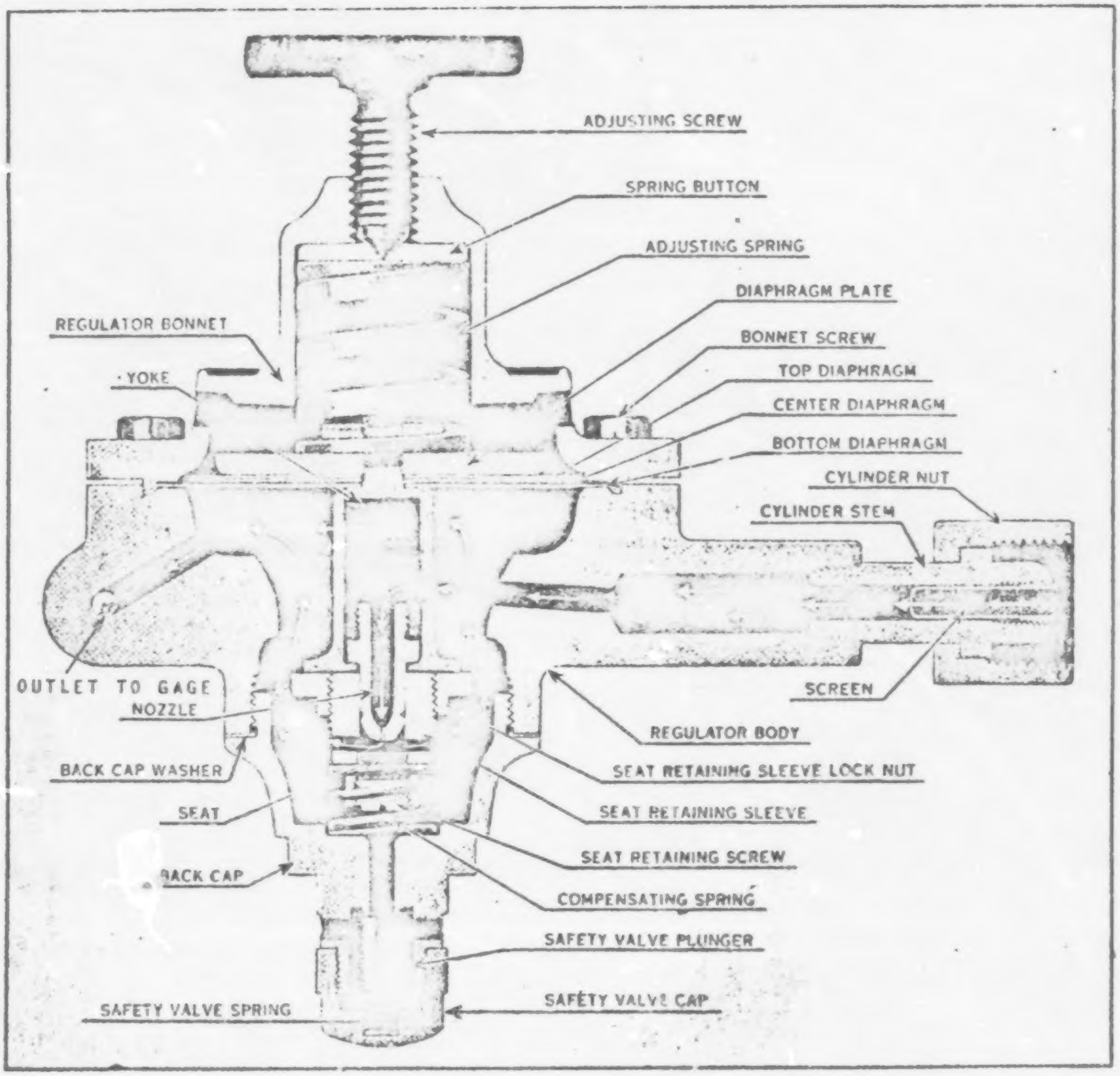

ADJUSTING SCREW
SPRING BUTTON
ADJUSTING SPRING
DIAPHRAGM PLATE
REGULATOR BONNET
BONNET SCREW
YOKE
TOP DIAPHRAGM
CENTER DIAPHRAGM
BOTTOM DIAPHRAGM
CYLINDER NUT
CYLINDER STEM
OUTLET TO GAGE
NOZZLE
SCREEN
REGULATOR BODY
BACK CAP WASHER
SEAT RETAINING SLEEVE LOCK NUT
SEAT
SEAT RETAINING SLEEVE
SEAT RETAINING SCREW
BACK CAP
COMPENSATING SPRING
SAFETY VALVE PLUNGER
SAFETY VALVE SPRING
SAFETY VALVE CAP

Figure 30. Cross Section, Single-Stage Regulator.

in (clockwise), by turning to the right, pressure is transmitted to the adjusting spring. The adjusting spring presses down upon the diaphragm, which in turn presses on the yoke and overcomes the pressure of the compensating spring. This forces the yoke forward, thus opening the passage through the nozzle and allowing the oxygen to flow into the low-pressure chamber of the regulator. The oxygen passes from here through the regulator outlet and hose to the torch. This pressure is indicated on the working pressure gage of the regulator and varies, depending upon the position of the regulator adjusting screw.

The regulator yoke and the seat movement is controlled by the compensating spring which pulls the seat to a closed position, and the adjusting spring which pulls the seat to a closed position, and the adjusting spring which tends to open it again. These springs act against each other and the position of the seat depends upon the pressure of the gas within the low-pressure chamber of the regulator. This pressure acts against the diaphragm and helps the compensating spring keep the seat closed. If the torch is shut off, the oxygen pressure on the diaphragm increases, overcoming the pressure on the adjusting spring to close the seat against the nozzle, preventing the pressure in the low-pressure chamber from rising further.

If the torch valve is reopened, the oxygen pressure on the diaphragm decreases, overcoming the pressure on the compensating spring and permitting the adjusting spring to move the seat away from the nozzle. This allows the oxygen to flow again and prevents the pressure in the low-pressure chamber from falling further. These operations of the regulator are entirely automatic, depending on the opening and closing of the torch valve. In normal operation, the pressure of the oxygen against the diaphragm and the springs is in a perfectly balanced condition when the seat is held slightly away from the nozzle. The smallest fluctuation of pressure brings about an instantaneous compensating movement of the diaphragm, springs, yoke, and nozzle, which immediately restores the pressure to the amount set.

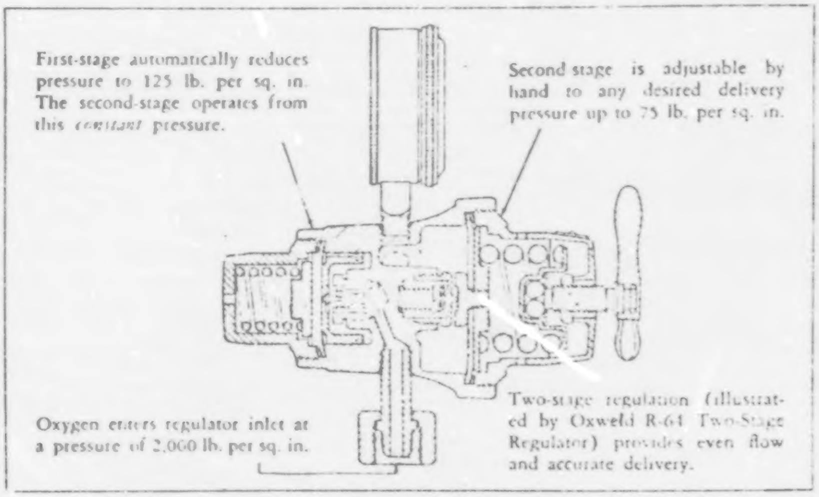

First-stage automatically reduces pressure to 125 lb. per sq. in. The second-stage operates from this *constant* pressure.
Second stage is adjustable by hand to any desired delivery pressure up to 75 lb. per sq. in.
Oxygen enters regulator inlet at a pressure of 2,000 lb. per sq. in.
Two-stage regulation (illustrated by Oxweld R-64 Two-Stage Regulator) provides even flow and accurate delivery.

Figure 31. Two-Stage Regulator.

TWO-STAGE REGULATOR. The operation of the two-stage regulator is identical in principle to that of the single-stage regulator. The only difference is that the total pressure drop takes place in two stages instead of one. In the high-pressure stage, the pressure is reduced from the intermediate pressure to the working pressure. The high-pressure stage has a set pressure reduction which is automatic, while the low-pressure stage is controlled with the adjusting screw to permit setting the proper working pressure as shown in figure 31.

GAGES. Oxygen and acetylene regulators are equipped with cylinder and working pressure gages. Although mechanical and operating principles of both regulators are the same, acetylene regulators are not designed to withstand the high pressures demanded of oxygen regulators. The acetylene high-pressure gages are usually graduated to 400 psi. Working pressure gages are generally graduated to 30 psi, although acetylene in the free state should not be used at pressures exceeding 15 psi.

Oxygen cylinder pressure gages usually have graduations in black figures to 3,000 psi, although the pressure within the cylinder does not exceed 2,000 psi at 70°F. The high-pressure gages are also graduated in red figures for cubic feet from 0 to 220. This permits the direct reading of cylinder pressure and oxygen content in cubic feet. The gages are graduated to indicate correctly at a temperature of 70°F. The working pressure gages for welding are generally graduated in pounds per square inch from 0 to 50. Regulators intended for use in heavy-duty cutting operations are graduated to indicate pressures as high as 400 psi.

Regulators used at stations to which gases are piped by manifold, or from acetylene generators, have only one gage. The regulators are used to regulate the working pressure of gases flowing through the distributing system to the torch. These regulators are of the single-stage type and are designed for low pressure since the line pressure set at the manifold or generator is less than 15 psi for acetylene and 100 psi for oxygen.

Torches

The oxyacetylene torch is used to mix oxygen and acetylene gases in definite proportions, and provides a means of directing and controlling the size and quality of the flame produced. Torches are produced in several sizes and consist of a handle equipped with two needle valves, one for adjusting the flow of acetylene and one for adjusting the flow of oxygen. In addition, they consist of hose connection glands, mixing head and retaining nut, mixing chamber, and a set of various size tips. Torches are classified as equal-pressure and low-pressure injector types.

INJECTOR TYPE. These torches operate on an acetylene pressure of less than one psi. They were originally designed for use with low pressure generators where higher acetylene pressures were not available. The acetylene, passing through relatively large openings is drawn into the mixing head by the suction created by the oxygen as it passes through the injector nozzle. The oxygen is under a much higher pressure, ranging from 10 to 40 psi, depending upon the tip size. The oxygen passing through a very small orifice in the injector nozzle at high velocity creates a vacuum effect that draws the required amount of acetylene into the mixing chamber.

EQUAL PRESSURE TYPE. These torches operate on an acetylene pressure of 1 to 15 psi, depending upon the tip size. The torch is designed to operate at equal pressures for both oxygen and acetylene. In this case, the openings at the torch needle valves are equal, and under equal pressures, deliver equal volumes of oxygen and acetylene to the mixing chamber. The mixing chamber serves only to mix the gases and in no way aids the flow of gases, as in the case of the injector torch. The equal pressure torch has certain advantages over the injector torch in that the type of flame desired can be more readily adjusted, and since equal pressures are used for both gases, the torch is less susceptible to flashbacks.

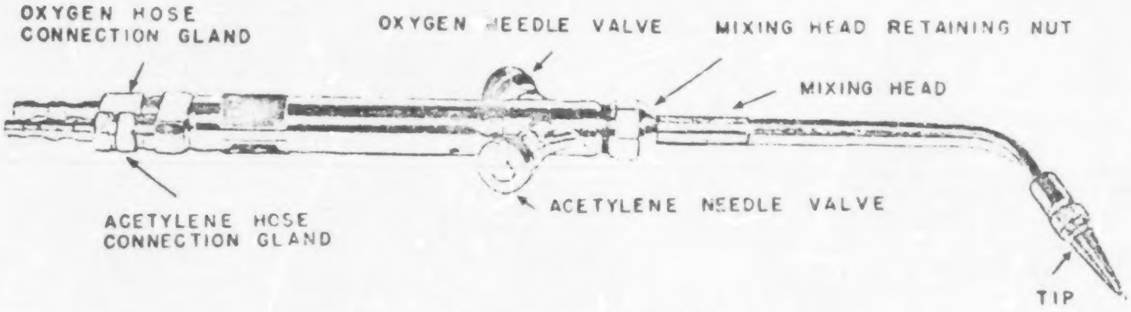

OXYGEN HOSE CONNECTION GLAND
OXYGEN NEEDLE VALVE
MIXING HEAD RETAINING NUT
MIXING HEAD
ACETYLENE HOSE CONNECTION GLAND
ACETYLENE NEEDLE VALVE
TIP

Figure 32. Oxyacetylene Torch.

The welding torch, as shown in figure 32, mixes the two gases together in correct proportions. It also provides a means of directing and controlling the size and type of welding flame produced.

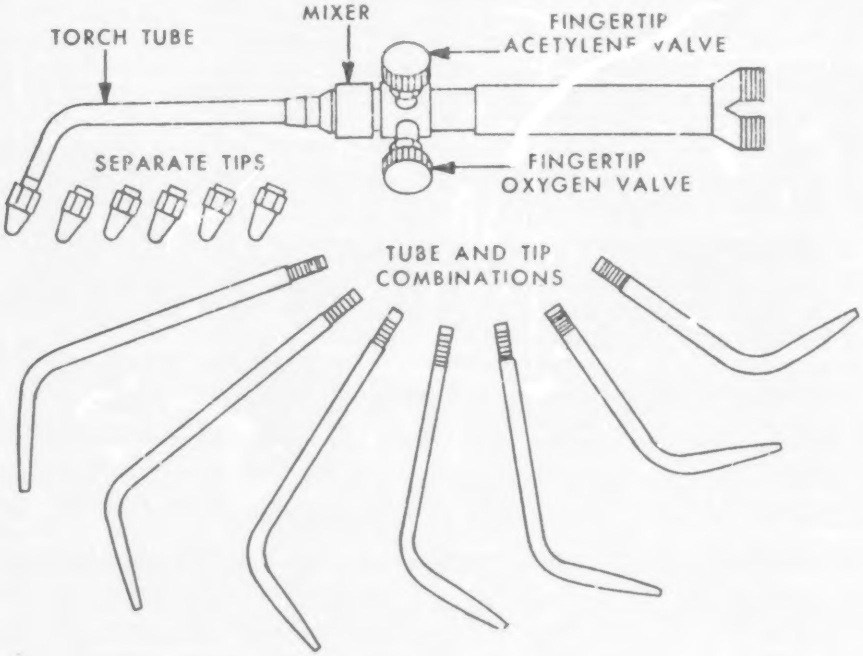

TORCH TUBE
MIXER
FINGERTIP ACETYLENE VALVE
SEPARATE TIPS
FINGERTIP OXYGEN VALVE
TUBE AND TIP COMBINATIONS

Figure 33. Modern Welding.

Torch Tips

Welding tips, shown in figure 33, are furnished in various styles or types, some have a one-piece hard copper tip, and others have a two-piece tip and mixing head combined. The tip sizes are designated by numbers, and each manufacturer has his own system for designating size. The tip sizes differ in the diameter of the orifice in order to obtain the correct volume of heat for the work to be done. Since welding tips are made of copper or brass, extreme care must be exercised to prevent damage to the tip or orifice. Tips should be cleaned with either a soft copper wire or a tip drill made specifically for cleaning the tip.

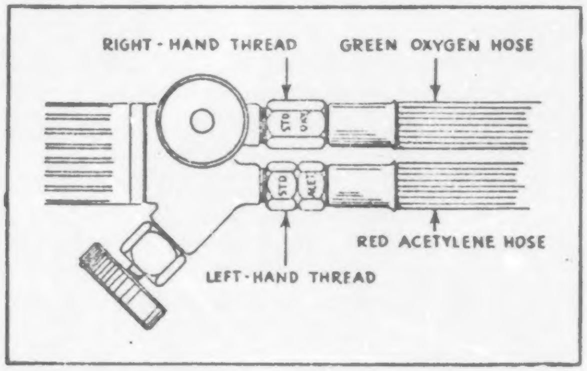


Figure 34. Torch Hose Connections.

Welding Hose

The hose which connects the torch and regulator is specifically manufactured for this purpose. It is strong, nonporous, and sufficiently flexible and light to yield readily to torch movements. It is constructed to withstand high internal pressures and the rubber used in its manufacture is chemically treated to remove sulphur in order to avoid any possibility of spontaneous combustion.

Welding hose is available in various sizes, depending upon the class of work for which it is intended. The size of the hose is designated by the inside diameter and the number of plies of fabric which it contains. The hose used for light torches is 1/8 to 3/16" in diameter and has one or two plies of fabric. The acetylene and oxygen hoses are the same grade but differ in color. The oxygen hose is green or black while the acetylene hose is red or maroon. Hoses are equipped with connections at each end in order that they may be attached to their respective regulator outlet and torch inlet connections. These connections consist of a swivel nut and gland. To prevent a dangerous interchange of welding hose, the threads on all acetylene hose connections, regulator outlets, and torch inlets are left hand threads and grooved to further simplify their identification, as shown in figure 34.

Starting Up a Stationary Welding Outfit

1. Check the hose lines to insure that each line is connected to the proper regulator outlet and torch inlet connection, and that the gland nuts are tight.

2. Check the torch valves to make sure that they are both closed.

3. Select the proper tip and attach it to the torch mixing head. Tighten it with the tip wrench.

4. Open the torch acetylene valve and adjust the acetylene regulator to give a working pressure needed for the tip size used.

5. Close the torch acetylene valve.

6. Open the torch oxygen valve and adjust the oxygen regulator to give the required working pressure.

7. Open the torch acetylene valve and light the gas with the igniter.

8. Adjust the acetylene valve to give a flow of gas sufficient to cause a slight gap between the end of the tip and the flame.

9. Readjust the acetylene torch valve to the desired flow of gas.

10. Open the oxygen torch valve slowly until the luminous central cone becomes well-rounded with no feather at the tip of the cone.

PORTABLE WELDING OUTFIT

A complete portable welding outfit, shown in figure 35, consists of the following items: a cart with a carbon dioxide fire extinguishers; a supply of oxygen and acetylene gas in cylinders; oxygen and acetylene pressure regulators complete with gages and connections; two lengths of hose with adapter connections for the regulators and the torch; an apparatus wrench; a safety flint igniter; and a pair of welding goggles.

There are many rules in regard to the care and handling of this equipment. You must continually be on the alert to insure that you are following these rules. Damage to any part of the equipment can put the whole outfit out of commission until that part is repaired or replaced. Setting up, turning on the gases, lighting the torch, and closing down a portable welding unit should be performed systematically in order to prevent damage to the equipment or injury to yourself. The following procedures are based upon years of experience and will assure operator safety and prevent damage to the apparatus.

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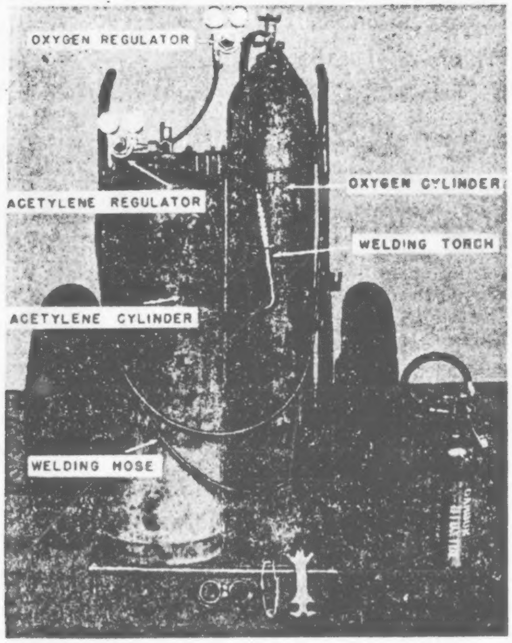
OXYGEN REGULATOR
ACETYLENE REGULATOR
OXYGEN CYLINDER
WELDING TORCH
ACETYLENE CYLINDER
WELDING HOSE

Figure 35. Portable Welding Outfit.

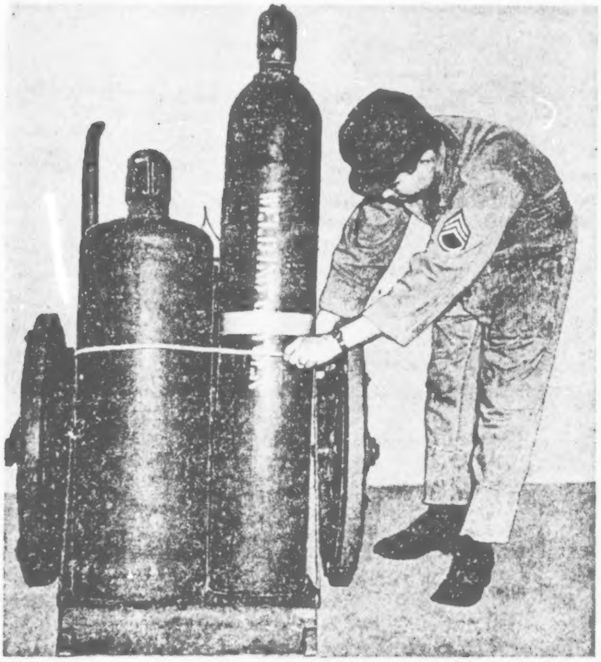

Figure 36. Attaching Cylinders to Truck.

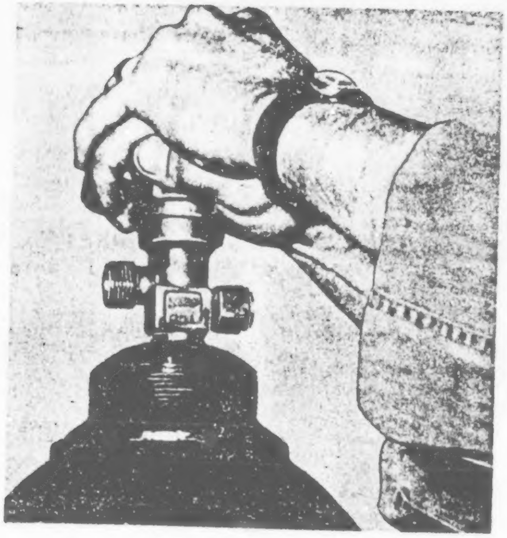

Figure 37. Blowing Out Dirt in the Outlet Nipple.

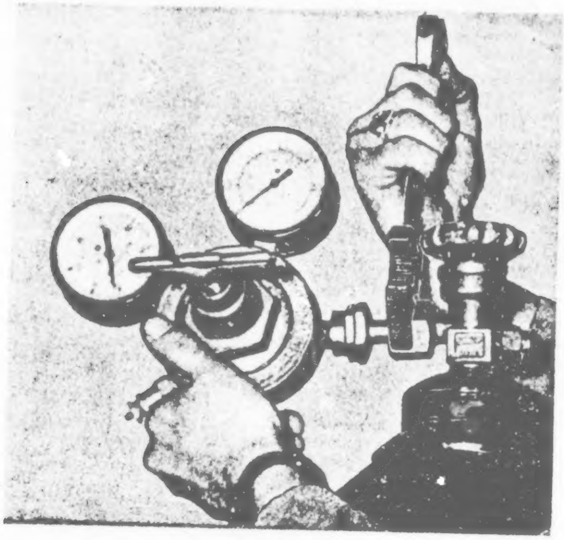

Figure 38. Tightening the Union Nut.

Assembling the Apparatus

1. Place the acetylene and oxygen cylinders on the cart, attaching them securely, figure 36. Remove the cylinder valve protection caps.

2. Open each cylinder valve slightly for an instant to blow out any dirt that may be lodged in the outlet nipple, figure 37.

3. Attach the regulators to their respective cylinders and tighten the union nut with the apparatus wrench, figure 38. Acetylene cylinder valves that have left-handed threads require an adapter between the cylinder valve outlet and the regulator.

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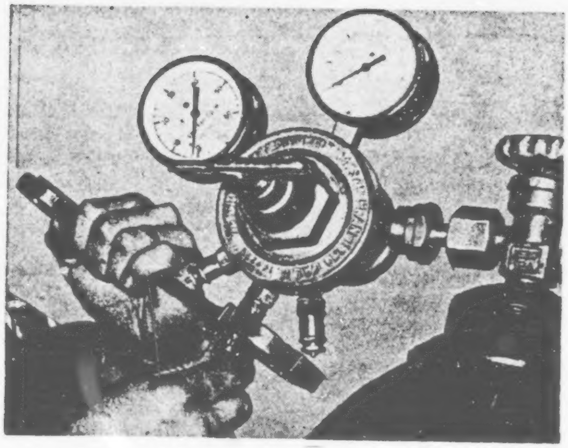


Figure 39. Attaching Hose to Regulator.

4. Attach the red acetylene hose to the acetylene regulator outlet which has left-hand threads. Attach the green oxygen hose to the oxygen regulator which has right-hand threads. Tighten the nuts with the apparatus wrench, figure 39.

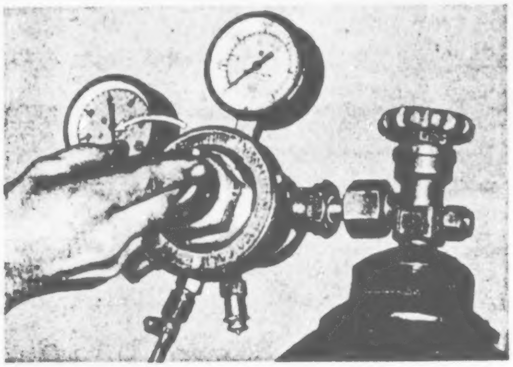


Figure 40. Releasing the Regulator Adjusting Screw.

5. Release the regulator adjusting screws by turning them counterclockwise until they are loose, figure 40. Open the cylinder valves slowly. Open the acetylene valve 1/2 turn and the oxygen valve all the way.

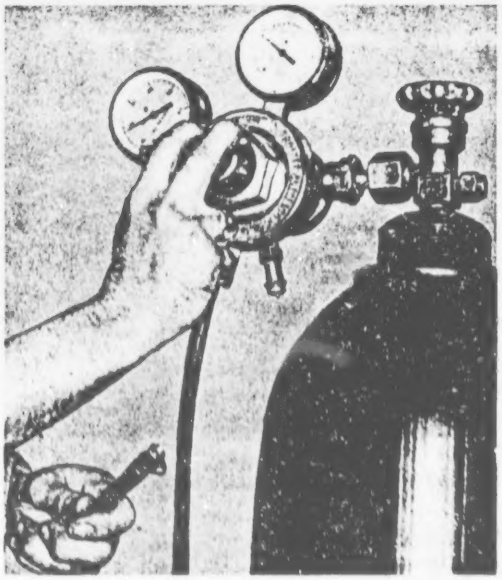


Figure 41. Blowing Out Hose.

6. Blow out the hoses one at a time, figure 41. Open each regulator by turning the adjusting screw clockwise. After blowing out the hoses, release the adjusting screws.

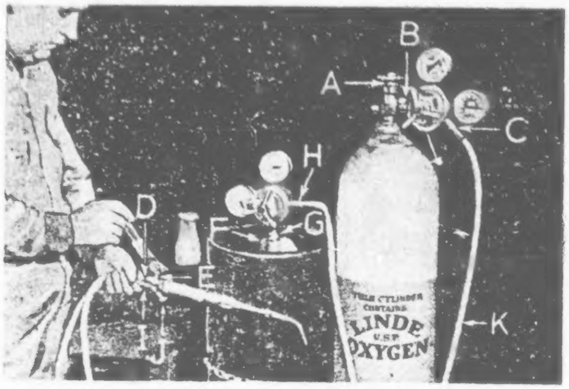


Figure 42. Check Points for Leaks.

7. Connect the red acetylene hose to the torch connection gland marked AC, and the green oxygen hose to the torch connection gland marked OX.

8. Select the proper size torch tip and attach it to the torch. Tighten it moderately with the apparatus wrench.

9. Adjust the regulators to the working pressures of the gases. Open the torch acetylene valve and adjust the regulator to the required pressure, then close the torch acetylene needle valve. Adjust the oxygen working pressure in the same manner.

10. To light the torch, open the torch acetylene needle valve and light it with the flint igniter, then adjust the needle valve to give a bright luminous flame.

11. To adjust the torch for the neutral welding flame, open the torch oxygen needle valve slowly until the feather at the end of the central cone disappears.

Testing for Gas Leaks

After assembling the apparatus, all connections should be checked for leaks before lighting the torch, as shown in figure 42. With the gas pressure adjusted to the working pressure, close the cylinder valves and release the regulator adjusting screw. A pressure drop on the working pressure gage indicates a leak between the regulator working pressure gage and the torch valves. A pressure drop on the high-pressure gage indicates a leak around the cylinder valve outlet. Gas leaks indicated by these methods can be located by applying a soap solution to the connections. A leak at any of the connections causes a soap bubble to form. Leaks in the welding hose can be located by immersing the hose in clean water using normal working pressures. Leaks in the hose are indicated by a string of bubbles.

Oxygen and Oxygen Cylinders

OXYGEN. Oxygen is a colorless, tasteless, and odorless gas, slightly heavier than air. It is one of the principle constituents of the atmosphere and the water. Oxygen is a very active element and combines with practically all materials under suitable conditions, sometimes with destructive results. Grease and oil are highly combustible in the presence of pure oxygen. Rust on ferrous metals, the dark discoloration of copper, and the corrosion of aluminum are all due to the action of oxygen in the atmosphere. This action is known as oxidation.

Commercial oxygen is chiefly used for welding and cutting with oxyacetylene torches. The value of oxygen lies in the fact that it supports combustion of the fuel gases in the process involved. Oxygen is obtained commercially either by the liquid-air process or by the electrolytic process.

The liquid-air process supplies most of the oxygen used for welding. In this process, air is compressed and cooled to a temperature -321°F when the gases become liquid. As the temperature of the liquid air is raised, the nitrogen, in a gaseous form, is given off first, since the boiling point of liquid nitrogen is -321°F. The oxygen is given off when a temperature of -297°F is reached. These gases, having been thus separated, are further refined and then compressed into cylinders for use.

In the electrolytic process, oxygen is obtained by separating water into hydrogen and oxygen by passing a direct current through the water to which an acid or alkali has been added. The electric current breaks the water down into its chemical elements of hydrogen and oxygen. The oxygen collects at the positive terminal, while the hydrogen collects at the negative terminal. Each gas, having passed through suitable pipes, is compressed into containers.

OXYGEN CYLINDERS. The bulk of commercial oxygen is supplied in seamless steel cylinders containing 220 cubic feet at a pressure of 2,000 psi at 70°F. A smaller oxygen cylinder containing 110 cubic feet at 2,000 psi at 70°F is also available for the convenience of users requiring small volumes, or for ease of handling for outside jobs.

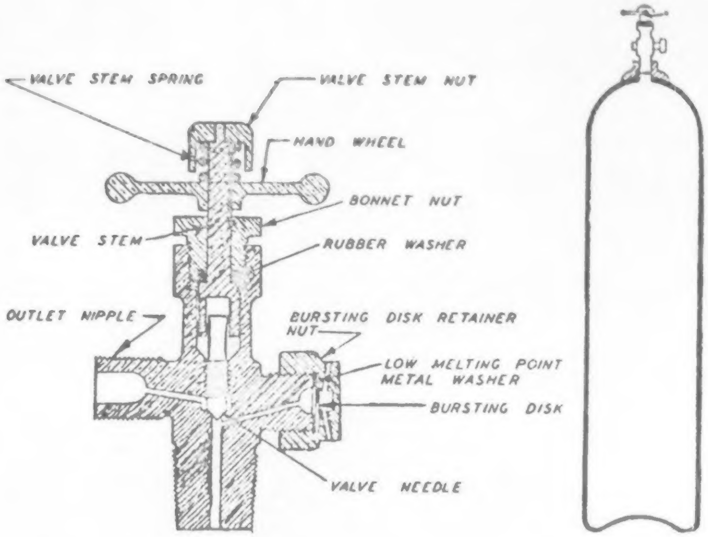


Figure 43. Oxygen Cylinder and Valve.

Figure 43 shows the construction of an oxygen cylinder and cylinder valve assembly. The valve shown is the needle-type and is made of high-strength, noncorrosive copper alloy. A bursting disc in the nipple at the rear of the valve consists of a thin copper diaphragm supported by a fusible alloy metal washer, and is held in place over the end of the nipple with a cup-shaped nut. The alloy washer melts at approximately 240°F, so that in the event the cylinder is exposed to a temperature above this point, the disc either bursts or flutters freely and releases the pressure before the expanding gas can reach a dangerous pressure in the cylinder.

Acetylene and Acetylene Cylinders

ACETYLENE. Acetylene is the fuel gas used in the production of the high-temperature oxyacetylene flame. It is a compound of carbon and hydrogen ($C_2 H_2$) which has two atoms of carbon combined with two atoms of hydrogen in its chemical structore. Acetylene is without color and has a distinctive odor that is easily detected even when it is diffused into the air. It is a stable compound under low pressure at normal temperature, but it becomes unstable when it is compressed in a container to a pressure exceeding 15 psi. Under a pressure of 29.4 psi, it becomes self-explosive, and a slight shock may cause it to explode even in the absence of oxygen or air. Mixtures of acetylene and air containing from 2 to 80 percent acetylene explode when they are ignited. The problem of storing acetylene under pressure has been overcome by dissolving it in acetone, which is capable of absorbing acetylene approximately 25 times its own volume.

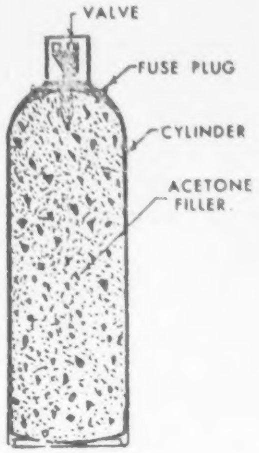


Figure 44. Cross Section of an Acetylene Cylinder Showing Filler Material.

ACETYLENE CYLINDERS. The cylinders which are used to store acetylene under pressure vary to some extent in size and appearance. Figure 44 shows the construction of an acetylene cylinder. The cylinders are of seamless steel construction and are filled with a substance having a porosity of 75 to 80 percent. This filler forms a large sponge for liquid acetone, which in turn absorbs the acetylene. The porous filler is charged to 40 percent of its liquid volume. This allows space for expansion since acetone increases in volume as it absorbs acetylene and shrinks as the acetylene is released.

When the cylinders are filled, the manufacturer determines the weight of acetylene dissolved in the acetone by using the factor of 14.5 cubic feet per pound at 70°F. To determine the amount of acetylene in the cylinder, the cylinder is weighed before and after filling. The difference in weight multiplied by 14.5 gives the volume of acetylene in cubic feet.

In order to prevent loss of acetone content, acetylene cylinders should be stored in an upright position so that the acetone collects in the porous material below the outlet valve. Acetone discharges with the acetylene gas unless it is allowed to stand in an upright position for some time.

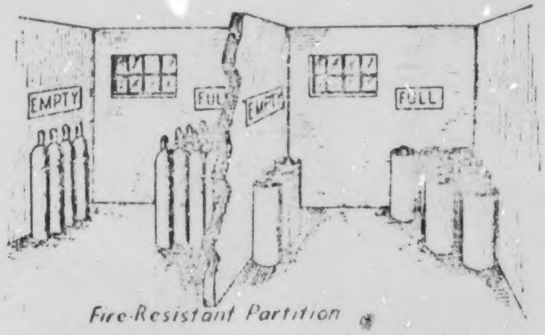
The rate of discharge of acetylene cylinders is also important. The cylinder discharge rate should not exceed 1/5 of the cylinder capacity per hour. If this rate is exceeded, the acetone may be drawn off with the acetylene gas. When higher discharge rates are required, acetylene cylinders should be set up and used from a manifold.

Acetylene cylinders are provided with safety plugs which are designed to release the gas from the cylinder if the cylinder becomes overheated. The metal alloy in these plugs melt at a temperature between 212° and 220°F. The plugs are small enough to cause the gas to escape at a speed that prevents the flame from burning back into the cylinder in case the escaping gas is ignited.

Storage and Handling of Oxygen and Acetylene Cylinders

1. Keep oxygen cylinders and all welding equipment away from oil and grease. Oxygen does not burn but it supports and accelerates combustion and causes oil and other similar materials to burn with great intensity.

2. Do not drop or handle cylinders roughly.



Cylinders should be stored in safe, approved places, provided with good ventilation. Keep full and empty cylinders separate. Return empty cylinders promptly to the oxygen or acetylene supplier.

Figure 45. Proper Storage of Oxygen and Acetylene Cylinders.

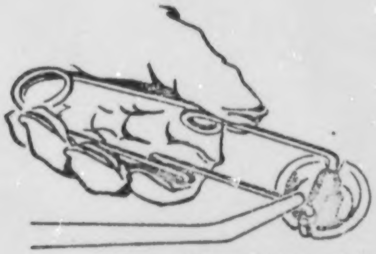
3. Do not store cylinders near a furnace or radiators. Excessive heat causes an increase in temperature of the compressed gases resulting in a corresponding increase in pressure in the cylinder. At abnormally high pressures and temperatures, the safety plugs release the gases from their containers.

4. Never attempt to repair cylinder valves.

5. Oxygen and acetylene cylinders should be separated in storage and used in order as they are received from the supplier, figure 46.

6. Acetylene cylinders should be stored and used in an upright position to prevent the loss of acetone.

7. When the cylinders are exhausted, replace the protective cap and mark the cylinders empty with the letters MT.



Use a friction lighter to light blowpipe. You might get a bad burn in trying to use a match.

Figure 46. Lighting the Torch.

Flame Adjustment

To light the welding torch, first open only the acetylene valve. The flame is obtained by striking the igniter in front of the tip, keeping the hand well to one side, as shown in figure 46. Hold the torch so that the flame will be directed away from you, the gas cylinders, hose, or any flammable material. The pure acetylene flame is long and bushy and has a yellowish color. Since the oxygen valve is closed at this time, the acetylene is combining with the oxygen in the air. This is not sufficient to burn the acetylene completely, and the flame is smoky and produces a soot of fine unburned carbon. The pure acetylene flame is unsuitable for welding.

The oxygen valve is then opened. This causes the flame to shorten, and the mixed gases burn in contact with the tip face. The flame changes to a bluish-white color and forms a bright inner cone surrounded by an outer flame envelope or sheath. The inner

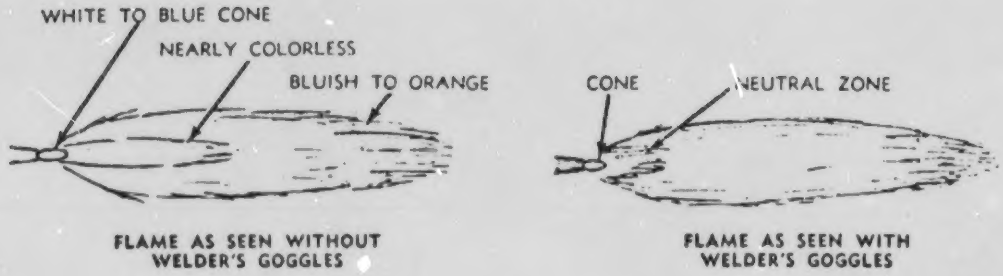

WHITE TO BLUE CONE
NEARLY COLORLESS
BLUISH TO ORANGE
CONE
NEUTRAL ZONE
FLAME AS SEEN WITHOUT WELDER'S GOGGLES
FLAME AS SEEN WITH WELDER'S GOGGLES

Figure 47. Neutral Flame.

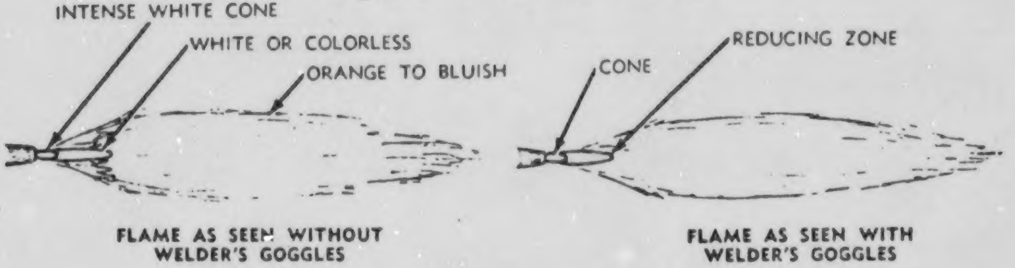

INTENSE WHITE CONE
WHITE OR COLORLESS
ORANGE TO BLUISH
CONE
REDUCING ZONE
FLAME AS SEEN WITHOUT WELDER'S GOGGLES
FLAME AS SEEN WITH WELDER'S GOGGLES

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Figure 48. Carburizing Flame.

cone develops the high temperature required for welding, while the outer envelope contains varying amounts of carbon soot, depending upon the proportion of oxygen to acetylene.

NEUTRAL FLAME. There are two clearly defined zones in a neutral flame. The inner portion consists of a luminous cone which is bluish-white in color. Surrounding this is a large envelope or sheath which is faintly luminous and has a light-bluish tint. The neutral or balanced flame is produced when the mixed gases consist of approximately one volume of acetylene, one volume of oxygen supplied from the torch, and 1 1/2 volumes from the atmosphere, as shown in figure 47.

In welding steel with a neutral flame, the molten pool of metal is quiet and clear, and the metal flames easily without boiling, foaming, or sparking. In a neutral flame, the temperature at the tip of the inner cone is approximately 5,850 degrees Fahrenheit.

CARBURIZING FLAME. The carburizing flame is produced when slightly less than one volume of oxygen is mixed with one volume of acetylene. This flame is obtained by first adjusting the welding flame to neutral and then further opening the acetylene torch valve slightly to produce a white streamer or feather of acetylene at the end of the inner cone. The carburizing flame can always be recognized by the presence of three distinct flame cones. They are the clearly defined bluish-white central cone, a white feather or intermediate cone indicating the amount of excess acetylene, and the light-blue outer flame envelope. This flame has a temperature of approximately 5,700 degrees Fahrenheit at the tip of the central cone, figure 48.

When a carburizing flame is used for welding steels, the molten metal becomes cloudy and numerous sparks are given off, caused by the steel absorbing carbon from the flame. This addition of carbon to the weld may cause the steel to become brittle and subject to cracking.

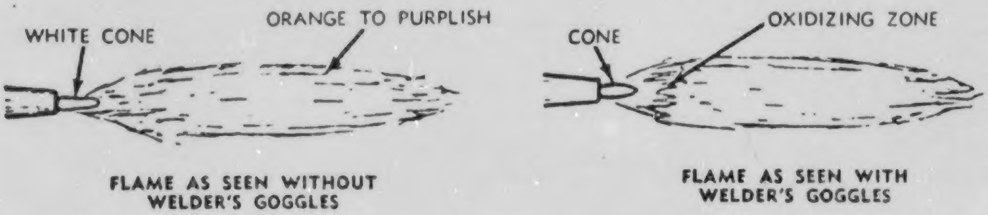

WHITE CONE
ORANGE TO PURPLISH
FLAME AS SEEN WITHOUT WELDER'S GOGGLES
CONE
OXIDIZING ZONE
FLAME AS SEEN WITH WELDER'S GOGGLES

Figure 49. Oxidizing Flame.

OXIDIZING FLAME. The oxidizing flame is produced when slightly more than one volume of oxygen is mixed with one volume of acetylene. To adjust for this type of flame, the torch should be first adjusted to give a neutral flame. Then increase the flow of oxygen by opening the torch oxygen valve. This flame can be recognized by a short, pointed central cone and a somewhat shorter outer flame envelope, and a distinct hissing sound, figure 49.

In welding steel, an oxidizing flame causes the molten metal to foam and give off sparks. This indicates that the excess oxygen from the flame is combining with the steel and is burning it. An oxidizing flame should not be used for welding steel since the deposited metal becomes porous, oxidized, and brittle. The temperature of this flame is approximately 6,300 degrees Fahrenheit.

Safety Precautions

1. Before lighting the torch, make sure that there are no leaks in the hose or connections to the torch or regulators.

2. Do not point the torch toward yourself, other workers near you, nor toward the hoses and regulators.

3. Always keep the torch within the line of your vision when it is burning.

4. Always turn off the torch before leaving your station.

5. Do not close the torch valves too tightly. Excessive pressure can damage the valve seats and cause them to leak.

DISASSEMBLY OF OXYACETYLENE WELDING EQUIPMENT

Closing Down a Stationary Welding Outfit

1. Close the torch acetylene valve.

2. Close the torch oxygen valve.

3. Shut off the acetylene regulator by turning the adjusting screw counterclockwise.

4. Shut off the oxygen regulator using the same procedure as described for closing the acetylene regulator.

5. Open the torch acetylene valve until the regulator gage shows no pressure, then close the valve.

6. Open the torch oxygen valve until the regulator gage shows no pressure, then close the valve.

7. Hang up the hose and torch, being careful to avoid kinking the hose.

Closing Down a Portable Welding Outfit

1. Close the acetylene needle valve first, then close the oxygen needle valve.

2. Close both of the cylinder valves.

3. Open the torch needle valves one at a time and bleed the hoses and regulators.

4. Close the torch needle valves.

5. Turn the regulator adjusting screws counterclockwise to relieve the pressure on the diaphragm.

6. Hang the torch and hose up properly to prevent kinking the hose and damaging the torch.

7. Disconnect acetylene hose from regulator.

8. Disconnect oxygen hose from regulator.

9. Disconnect regulator from acetylene tank, then disconnect the oxygen regulator.

10. Replace protective caps on tanks.

CARE AND MAINTENANCE OF OXYACETYLENE WELDING EQUIPMENT

The parts of the welding equipment are designed and constructed to exacting specifications and must not be used for any other purpose. Each part should be checked daily to make sure it works properly and has no gas leaks. The parts needing regular inspection and maintenance are the regulators, torches, tips, and welding hoses.

Regulators

The primary trouble experienced with regulators is gas leakage between the regulator seat and nozzle. You can detect it by a gradual pressure rise on the working pressure gage after the cylinder valve is opened. This is known as "creeping regulator" and is caused by worn or cracked seats, or dirt particles lodged between the seat and nozzle. Leaking regulators should be replaced in order to avoid damage to other parts of the welding equipment.

Gages

Problems with the gages are usually caused by a leaking or broken bourdon tube. Defective bordon tubes are indicated by fluctuating gage pressure or gas leaking from the gage case. This defect is caused by failure to fully release the adjusting screw before opening the cylinder valve. A leaking gage tube can be repaired by soldering. More extensive repairs should not be done without the special equipment required.

Torch

The primary cause of torch troubles are leaks in the mixing lead seat, leaking needle valves, and clogged torch tubes. A leaking needle valve is indicated by the gas flowing after the valve is closed. This is caused by a worn or bent valve stem, a damaged valve seat, or loose packing around the needle valve. A leak in the mixing head seat allows the gases to escape and unless you correct the trouble immediately, it can result in severe burns or damage to the equipment by flashback, which is the gas burning back into the torch.

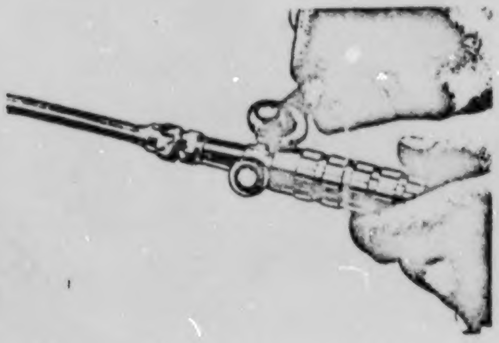


Figure 50. Tightening Packing Gland Nut.

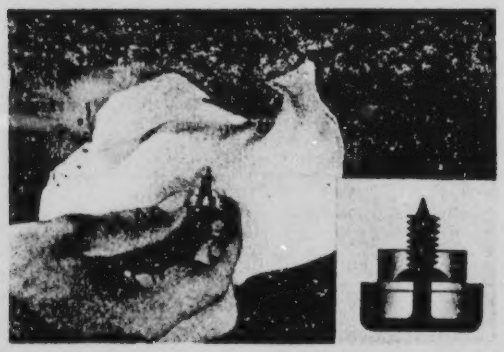


Figure 51. Inspecting Needle Valve Assembly.

Needle valve leaks around the seat may be repaired by tightening the packing gland nut, figure 50. If the leak is in the seat, remove the needle valve with a wrench and clean it, figure 51. If it worn or pitted, replace it with a new one. If the valve seat is scored, pitted, or otherwise damaged, the torch should be returned to the manufacturer for repair.

Leaking mixing head seats should be removed and cleaned. If the seats are damaged, the torch should be returned to the manufacturer for repair.

Clogged torch tubes should be cleaned by removing the hoses and mixing head, then blowing out each tube with 20 to 30 pounds of oxygen pressure.

Torch Tips

Scored or out-of-round tip orifices cause the flame shape to be irregular even after the tip has been cleaned. Tips require cleaning often because small particles of metal or oxide collect on the tip and in the orifice. Use soft copper wire or drill-type tip cleaner to clean the tip orifice. The cleaning drill should be approximately one size smaller than the tip orifice so that it does not enlarge the orifice during cleaning.

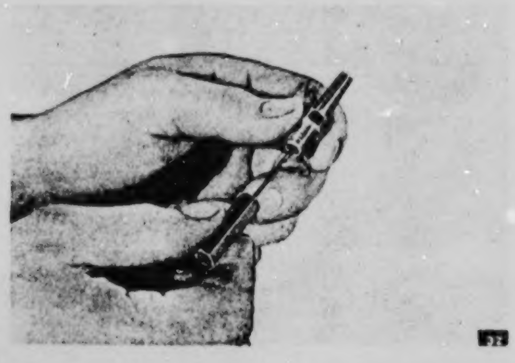


Figure 52. Cleaning a Torch Tip.

The dirty tip should be removed from the torch and the tip cleaner inserted in the threaded end, figure 52. The cleaner should be moved back and forth without twisting because this would enlarge the tip orifice. If the tip orifice is scored, out-of-round, or enlarged, the tip should be replaced.

Hoses

The welding hose should be checked at regular intervals for leaks, worn spots, or loose connections. Leaks in the hose can be found by immersing it in clean water under pressure. Since worn or leaking hoses are dangerous and wasteful, they should be repaired or replaced immediately.

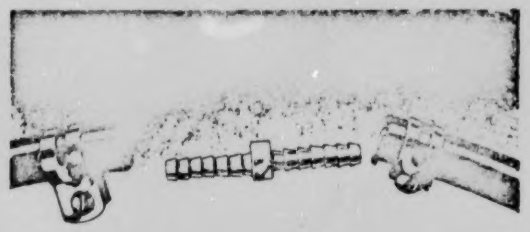


Figure 53. Repairing a Leaking Hose.

Leaks in the hose can be repaired by removing the damaged section and inserting a hose splice, as illustrated in figure 53. Hoses leaking at the regulator or torch connections are repaired by cutting off one or two inches and replacing the connections.

Procedure

1. Set up and operate a stationary gas welding outfit. You will be required to operate the unit systematically in starting up and closing down each day. Treat the unit as if it were your own; operate it safely and keep your area clean.

2. Light the torch and adjust the flame to neutral, oxidizing, and carburizing. Use goggles when you look directly at flame. Practice visual identification of each.

3. Direct a neutral flame on the surface of carbon steel sheet and note the behavior of the metal. Repeat for the oxidizing and carburizing flames, and note the reaction of the molten metal to each.

4. Close down the welding outfit and place the torch in a bench hanger.

SAFETY RULES FOR THE OPERATION AND MAINTENANCE OF STATIONARY AND PORTABLE OXYACETYLENE WELDING OUTFITS

1. Regulators are to be used only for the gases for which they are intended.

2. Welders must know the identifying characteristics of both oxygen and acetylene regulators.

3. The regulator adjusting screw must be fully released before opening cylinder valves preparatory to using the torch.

4. Cylinder valves should be opened slowly; the oxygen valve should be opened fully, and acetylene valve not more than one and one-half turns.

5. The acetylene cylinder valve wrench must be left in place on the acetylene cylinder valve so that the acetylene can be shut off quickly in case of an emergency.

6. Before the gases are ignited, all regulator hose and torch connections should be checked for leaks.

7. Only friction flint lighters should be used for lighting torches.

8. The student study guide should be followed in lighting torches and closing down torches.

9. The welder should always keep the flame in his field of vision.

10. Surplus hose should be coiled and out of the way of sparks and the flame.

11. Approved welding goggles must be worn during welding or cutting with oxyacetylene equipment.

12. When a flashback occurs, both torch valves must be shut off immediately, the acetylene valve first and then the oxygen valve. The torch should then be cooled and inspected before relighting.

13. When a backfire occurs, the tip size should be decreased or the pressure and volume of gases increased to overcome the burning back into the tip chamber.

14. A pilot flame must never be allowed to burn at the tip of the torch.

15. When a job is completed, the cylinder valves must be closed; the regulator hose and torch should be bled to release the gas pressures; the regulator adjusting screws should be fully released; and the torch valve should be closed.

16. A torch should never be left in the open end of a pipe, in a tank, or in other vessels, because a leaking hose or torch may cause the accumulation of an explosive mixture of gas.

17. When any part of the equipment requires maintenance work, the cylinder valves must be closed.

18. Leaking hoses should never be repaired with ordinary friction tape.

19. Copper tubing should not be used to splice acetylene hoses as an explosive gas (copper acetylite) may be generated.

20. Only commercial bronze, brass, or steel fittings should be used in setting up or repairing oxyacetylene welding equipment.

21. Spare parts and regulators should be stored in a clean, dry place free from contact with oil or grease.

22. Only soapy water should be used to test for leaks on oxyacetylene welding equipment.

23. Faulty regulators must not be used and only qualified personnel may make repairs on regulators.

24. Flashback arrestors, bursting discs, and reverse flow valves should be part of stationary welding outfits as added safety features.

25. The acetylene operating pressure should never exceed 15 lbs per square inch on oxyacetylene equipment.

Metallurgy Branch
Chanute AFB, Illinois

3ABR53230-SG-107

BEADS AND LAP JOINTS OF CARBON STEEL

OBJECTIVES

After completing this study guide and your classroom instruction, you will be able to apply the fundamental principles and techniques of welding lap joints of carbon steel in the flat position.

INTRODUCTION

The lap joint is probably the simplest joint used in any welding operation. The requirement of the lap joint is fairly simple. The joint edges should overlap at least three times the thickness of the metal. Beyond this, there are no requirements other than the weld bead itself. Since there are no joint edges to prepare, the lap joint can be easily and quickly welded.

INFORMATION

The oxyacetylene welding process requires a high temperature flame, produced by a mixture of oxygen and acetylene gases to melt the edges of the metal to be joined. The molten edges flow together producing one continuous piece of metal as the weld cools and hardens. The type of joint you weld determines whether or not you need a filler rod.

When you weld steel with the oxyacetylene flame, there are certain precautions that you should follow. They help you to improve your skill in controlling the motion of the flame, rod, and molten pool, and enable you to produce sound welds. You should observe the following precautions:

1. Use a strictly neutral flame for welding carbon steel.

2. The tip size should be large enough to melt the metal and allow complete fusion of the filler rod and base metal.

3. Do not use excessive gas pressure because this causes a harsh flame, making it difficult to control the molten pool.

4. The molten pool should progress evenly down the joint.

5. Hold the inner core of the flame slightly above the molten pool. Do not let it touch the filler rod, molten pool, or base metal. Protect the molten pool with the outer flame envelope.

6. Add the filler rod to the leading edge of the molten pool. Do not melt the filler rod and let it drop into the molten pool.

TEMPERATURE EFFECT ON METALS

Depending upon its composition, steel, when heated with the oxyacetylene flame does not become fluid until it reaches a temperature between 2450° and 2750°F. Knowing this fact allows you to control the molten pool when you are welding carbon steel in any position other than flat.

Heat Conductivity

KIND OF METAL	MELTING POINT (F°)	LINEAR EXPANSION (Per Ft. Per 1000° F.) Approx.	HEAT CONDUCTIVITY (Per Cent) (Based on Silver - 1000)
Aluminum, Pure	1218	.148 (9/64")	486
Aluminum, 5% silicon	1118	.148 (9/64")	
Brass	1650 to 1850	.115 (7/64")	150 - 300
Bronze	1650 to 1932	.119 (1/8")	
Copper	1981	.106 (7/64")	913
Gold	1930	.106 (7/64")	700
Iron, gray cast	2200 to 2400	.067 (1/16")	112
Iron, malleable	2300	.067 (1/16")	110 - 118
Lead	621	.188 (3/16")	83
Magnesium (alloy)	1204	.171 (11/16")	376
Molybdenum	4620	.098 (3/32")	
Monel metal	2480	.092 (3/32")	35
Nickel	2646	.083 (5/64")	140
Silver	1761	.129 (1/8")	1000
Silver solders	1160 to 1600		
Solder 50-50	437		
Steel (carbon)	2480 to 2750	.076 (5/64")	108
Stainless steel (18-8)	2640	.114 (7/64")	43
Tin	450	.139 (9/64")	152
Tungsten	6152		
Vanadium	3182		
White metal	430 to 490		
Zinc	786	.169 (11/64")	281

Table 1. Properties of Metal.

Heat conductivity is the speed with which heat travels through metal. Heat travels through some metals faster than others. The heat conductivity for the most common metals is shown in table 1.

These figures are based upon the heat conductivity of silver which is 1000 or 100%. Heat conductivity of metals should be considered in welding for two reasons.

1. Metals which have a high conductivity require a greater amount of heat because a great amount of the heat is conducted away from the point of heat application.

2. High conductivity causes the heated area to become larger and hotter causing a greater amount of expansion.

Expansion

Metals are sensitive to temperature changes. They expand under the application of heat with an increase in length, thickness, and width. If the temperature of a metal is raised uniformly throughout its mass and lowered in the same way, the force of expansion has no adverse effects when the heat from the welding flame is concentrated on a metal at one point, the metal in the heated area tries to expand and the part which opposes it either distorts out of shape, breaks, or is severely stressed. Each metal expands a definite amount for each degree of rise in temperature. The increase in length per inch per degree of temperature rise measured in millionths of an inch is called the coefficient of expansion. The coefficients of expansion for the common metals are given in table 1.

Contraction

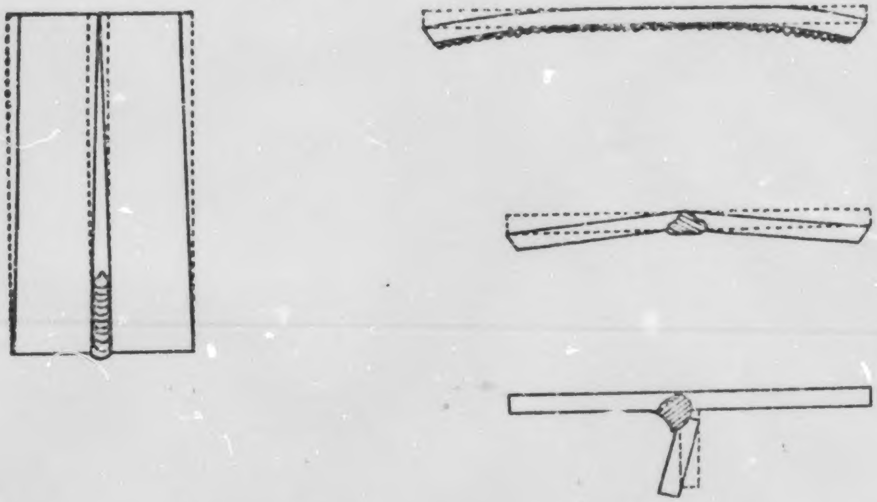


Figure 54. Results of Weld Metal Shrinkage.

Contraction is the reverse of expansion. When it is cooled from the welding temperature, the metal contracts as much as it expanded. If the temperature is uniform throughout the part, contraction is not restrained. If contraction is restrained, the metal part is pulled out of alignment or a high stress remains, reducing the strength of the weld and causing the metal to break at a weaker point. Figure 54 illustrates how contraction of the weld metal pulls the parts out of alignment when no provision is made to prevent it. The effects of contraction can be best controlled by slow, even cooling. Allowances can be made to cause the shrinkage of the weld to pull the members into alignment.

CONTROLLING EXPANSION AND CONTRACTION

Fixtures

Joints in sheetmetal should be welded in a fixture whenever possible. A properly designed fixture holds the edges in alignment and minimizes the flow of heat into the sheet, reducing the amount of expansion and contraction. The clamping action of the fixture prevents undue movement of the parts, while the use of heavy sections in the fixture at the desired points effectively removes the heat from the base metal.

Stress Relieving

In most cases, there is some stress remaining in parts fabricated or repaired by welding. When it is practical, this stress should be relieved in order to obtain the full strength of the weld and the base metal. Heat treatment is the most reliable method of stress relieving. The part can be heated in a furnace to the stress-relieving temperature, then cooled slowly and evenly. When this is impossible, stress-relieving can be done by reheating the entire weld to a dull red heat with the welding torch, then allowing it to cool slowly. In many cases, distortion can be relieved or eliminated in welded steel structures. After completing each weld, direct the flame on the back side of the weld. This controls shrinkage and, offsets some of the warpage caused by welding. Warped or buckled plates can be straightened in a similar manner.

Stress Distribution

Additional weld metal above the minimum requirement for reinforcement does not necessarily mean added strength of the joint. A uniform weld contour is essential to transmit stresses through the face of the weld points of stress concentration occur wherever there is an abrupt change in the contour of weld reinforcement. Gradual changes in the weld contour and the omission of internal and external irregularities in a weld result in good stress distribution.

Strength of Welded Joints

The strength of a welded joint is affected by the weld metal deposit, type of joint, size of the weld, location of the weld in relation to the parts, kind of stresses which the joint is subjected to, and the skill of the operator. Most welded joints can be made as strong as the base metal if the proper amount of weld reinforcement is used.

Location of Welds

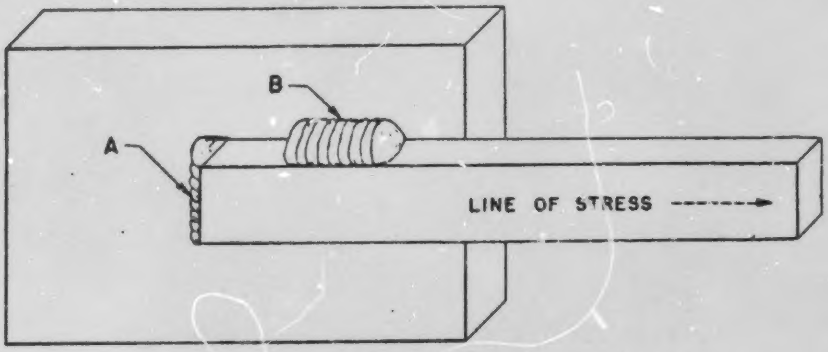


Figure 55. Location of Welds in Relation to Line of Stress.

The location of the weld can affect the strength of the joint. Welds that are made across the line of stress, shown in figure 55, are usually 30% stronger than welds that are made parallel to the line of stress, shown in figure 55B.

Welds running parallel to the stress line have more stress on the ends of the weld than the middle and have a tendency to tear out. If your welds have to run parallel to the line of stress, you can hook them around the joint to reduce this tendency to tear.

TERMINOLOGY

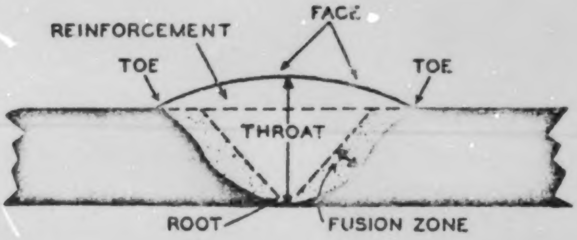


Figure 56. Cross Section of a Weld.

Each weld must meet certain specifications. To obtain maximum weld strength, the established specifications for reinforcement, penetration, and contour must be met. References to specifications of a weld are based on "T" which is the thickness of the base metal. The different parts of a weld are shown in figure 56. The terms are defined as follows:

1. Fusion Zone - The area of weld metal that has penetrated beyond the original surface of the base metal.

2. Root - The portion of the weld metal deposited at the bottom of the joint.

3. Throat - The distance along the center line of the weld between the root and the face.

4. Weld Reinforcement - Metal added above the surface of the joint edges.

5. Face - The outer surface of the weld reinforcement.

6. Toes - The edges of the weld face.

7. Leg - The dimension of the weld extending on each side of the root of the joint. This applies to lap joints.

8. Penetration - The distance from the original surface of the base metal to the point at which fusion ceases.

WELDING METHODS

Forehand Welding

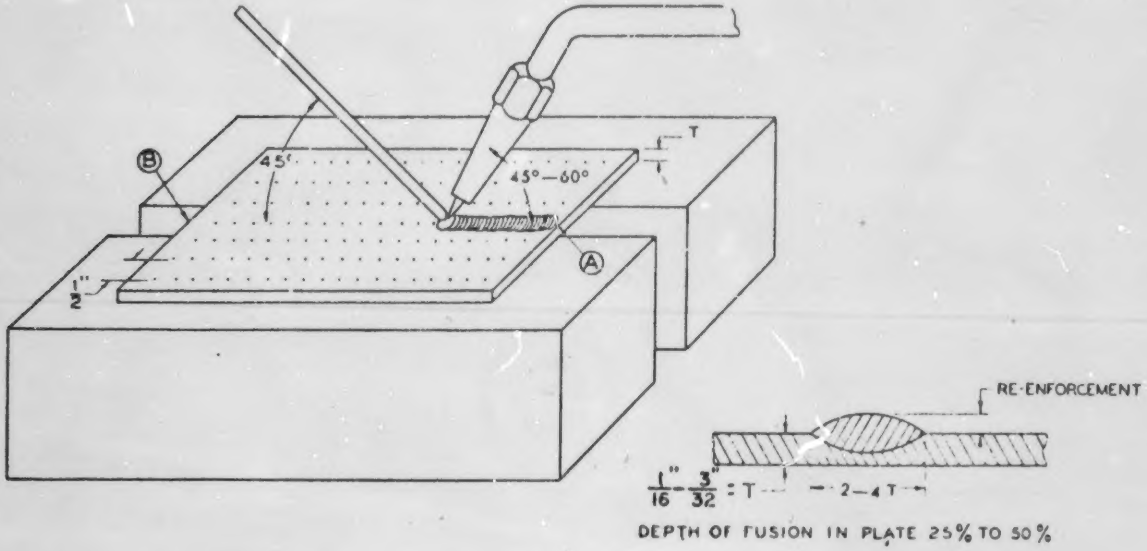
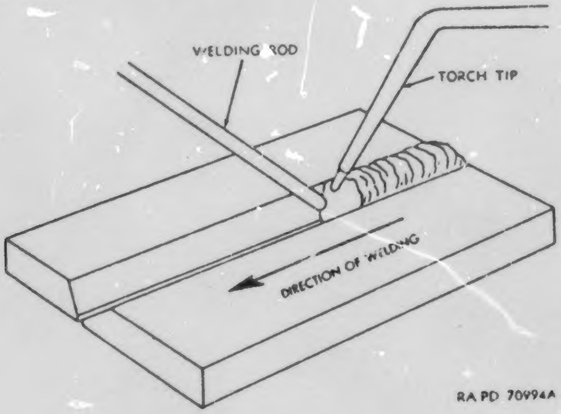


Figure 57. Welding Beads, Forehand Method.

In this method, the flame is pointed in the direction of travel and the tip is held at an angle of approximately 45° to 60° to the work. This angle allows the welding flame to preheat the metal ahead of the molten pool, as shown in figure 57.

The angle of the filler rod should be 45° to the plate surface but may vary slightly on different jobs. The filler rod is added to the molten pool by dipping it in the leading edge of the molten pool. This welding method is most commonly used on thin-wall tubing, sheetmetal, and plate up to 1/4" thick.

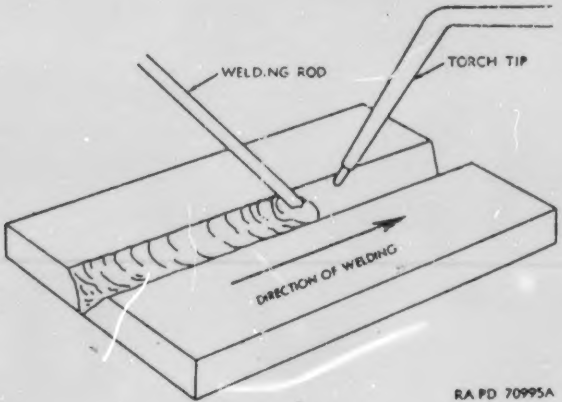

WELDING ROD
TORCH TIP
DIRECTION OF WELDING

RA PD 70994A

Figure 58. Forehand Welding.

In plates over 1/4" thick, a wide bevel with a 90° included angle must be used to insure proper fusion and penetration of the base metal, as shown in figure 58. This causes the molten pool to become large and difficult to control.

Backhand Welding


WELDING ROD
TORCH TIP
DIRECTION OF WELDING

RA PD 70995A

Figure 59. Backhand Welding.

In this method, the flame is directed back toward the finished weld, as shown in figure 59. Backhand welding is used primarily for heavier metal because the edge bevel does not exceed 60° included angle. This permits you to maintain a smaller molten pool and uses less filler rod.

Without filler rod

1. Light the torch and adjust it to a neutral flame.

2. Heat the plate until a molten pool is formed.

3. Using a slight circular motion, move the torch in the direction of the weld.

4. To make a narrow bead, hold the flame close to the molten pool. To make a wide bead, hold the flame away from the molten pool.

With filler rod

1. Light the torch and adjust it to a neutral flame.

2. Heat the plate until a molten pool is formed.

3. Dip the filler rod in the leading edge of the molten pool.

4. Move the torch slightly from side to side to obtain good fusion.

Torch Tip Selection

METAL THICKNESS	TIP SIZE NO.	
	Torchweld	Airco
1/64" to 1/32"	72	0
1/32" to 1/16"	68	1
1/16" to 1/8"	62	2
1/8" to 3/16"	58	3
3/16" to 1/4"	55	4
1/4" to 3/8"	53	5

Table 2. Tip Sizes.

The selection of the proper tip size depends upon the thickness of the base metal and the rate at which the heat is conducted away from the weld. When the tip is too large, the metal is overheated, scales, and some of the elements are burned out of the metal, causing a weak weld. When the tip is too small, the volume of heat is not sufficient to obtain proper fusion. Torch manufacturers furnish tables giving the approximate sizes of tips for welding different thicknesses of metal. The approximate tip size for steel may be selected by referring to table 2.

Filler Rod

METAL THICKNESS	FILLER ROD
1/16" to 1/8"	1/16" to 3/32"
1/8" to 1/4"	1/8"
3/8" to 1/2"	3/16"
1/2" and up	1/4"

Table 3. Size of Filler Rods.

The type of filler rod for any job depends upon the metal to be welded. In most cases, the filler rod is the same composition as the base metal. The copper coated low carbon filler rod is used to weld low carbon steel. Filler rods are available in diameters from 1/16" to 3/8". The size of the filler you use is determined by the thickness of the base metal. Table 3 shows the comparison between metal thickness and filler rod diameters.

WELDING LAP JOINTS

A lap joint, the edges of two sheets are placed one above the other, and the weld applied joining the edge of one sheet to the surface of the other. Lap joints are used in the construction of equipment fabricated from plate and sheet metal. Lap joints are not as efficient in the transmission of load stresses as are butt joints, but certain types of lap joints develop the full strength of the base metal under a tensile pull.

Types of Lap Joints

SINGLE-FILLET LAP JOINT. This type of joint is frequently used, since it requires no machining of the joint edges. This joint is welded from one side only when the design of the part does not permit welding from both sides. The single-fillet lap joint, figure 60A, does not develop full base metal strength, but is stronger than a butt weld for some applications. When tubing or frames overlap or telescope together, the lap joint is preferable to the butt joint. If loading is not too severe, this joint is suitable for welding metals of all thicknesses. If fatigue or impact loads are encountered, concentration of

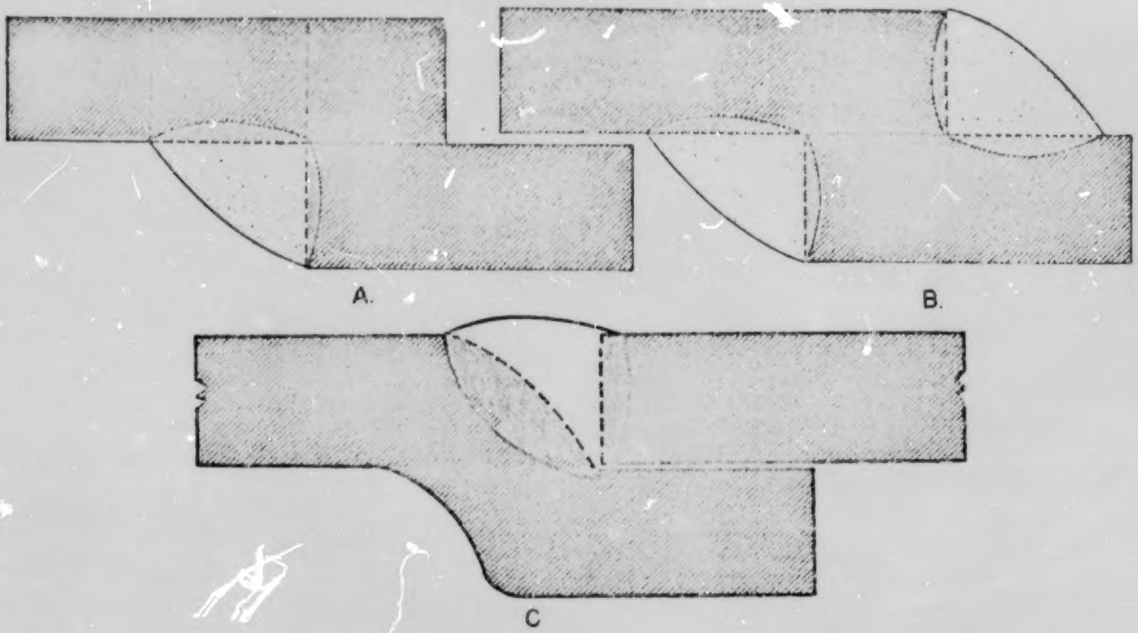


Figure 60. Types of Lap Joints.

stress occur at the edge of the weld. Under tension the plates may pull out of line, subjecting the root to bending.

DOUBLE-FILLET LAP JOINT. This joint, figure 60B, is suitable for much more severe load conditions than can be met by the single-fillet lap joint. When properly made, this joint develops the full strength of the base metal. However, for extremely severe loads, the butt joint is preferred.

JOGGLED LAP JOINT. When you want to use a lap joint but the metal surface must be kept on the same plane, the joggled lap joint, figure 60C, is used. This joint gives a more uniform distribution of load stresses than the single or double-lap type. The joint produces a greater strength than the single-fillet lap joint, but is more difficult to prepare for welding.

Weld Specifications

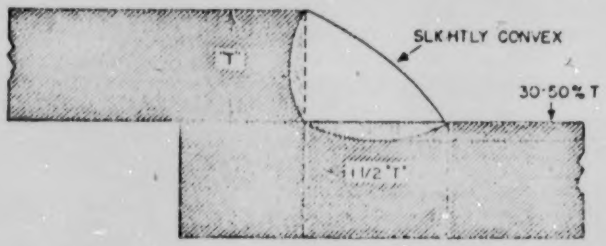


Figure 61. Weld Specifications.

1. The upper leg should equal the base metal in thickness, the lower leg 1 1/2 "T," figure 61. When welds are made on

metals of unequal thickness, the specifications are based upon the thickness of the lighter gage sheet.

2. The face should be slightly convex in shape.

3. Penetration for metals 1/8 inch or less should be 30 to 50% of the metal thickness. For heavier gages the minimum penetration is 1/16 inch.

4. The throat thickness should equal the thickness of the base metal.

Welding Technique

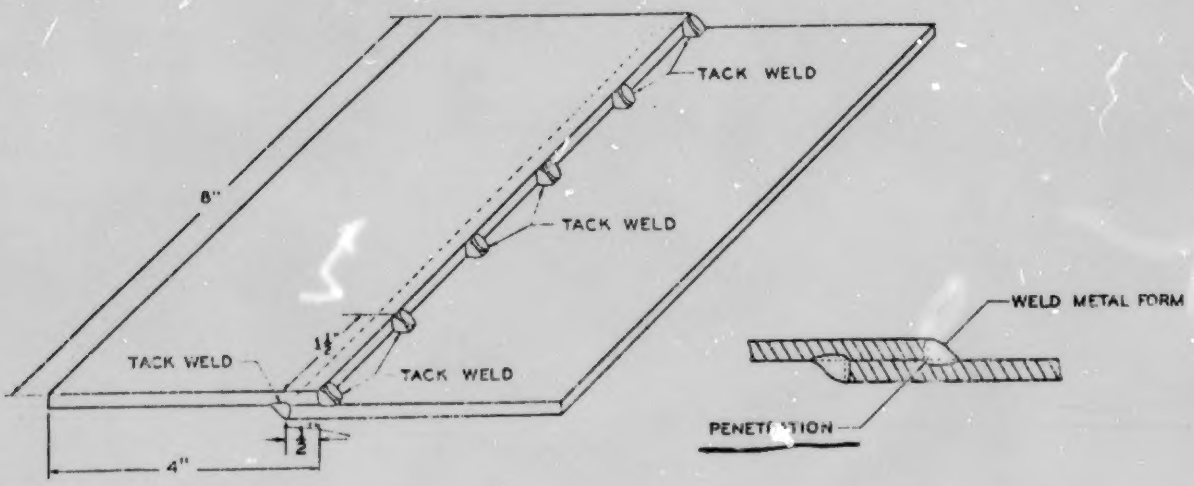


Figure 62. Lap Joint.

When joining metal thickness of 1/8 inch or less, the overlapping of the sheets should be from 4 to 6 times the metal thickness. The joint should be tack welded at intervals of approximately 1 1/2 inches as shown in figure 62. Prior to welding, the edges of the sheet should be preheated by directing the flame above and below the joint.

Backhand Welding

In this method, the flame is directed back toward the finished weld. Backhand welding is used primarily for heavier metal because the edge bevel does not exceed 60° included angle. This permits you to maintain a smaller pattern pool and uses less filler rod edges. This will raise the temperature of the metal to a point which will permit obtaining fusion into the root of the joint. The torch should be held approximately 60 degrees from horizontal, thereby directing most of the welding heat upon the bottom sheet, with the flame pointed in the direction of travel. When the edges are raised to the molten state, the center of the molten pool should be in line with the unmelted upper edge of the joint. This procedure permits a greater amount of the base metal to be melted into the molten pool, thus requiring less filler rod and assuring adequate fusion into the upper sheet. To prevent possible undercutting at the upper edge of the joint and overlap on the lower plate, the filler rod should be added to the upper edge of the molten pool. The speed of travel can be determined by the size of the molten pool maintained at the joint edges. The following weld characteristics can be used in determining wrong techniques employed in making lap welds.

Concave Weld Face: This condition generally indicates the use of too large a welding tip and/or an insufficient amount of filler rod added to the weld. It results in excess penetration and undercutting at the toes of the weld.

Weld Face Excessively Convex: This welding heat and adding an excessive amount of filler rod. Overlap and lack of penetration results.

Undercutting and Overlap: This condition exists when the flame is directed improperly. Undercutting occurs on the overheated edge and overlap on the edge insufficiently heated. This same condition may result from the improper addition of filler rod into the molten pool.

Narrow and Wide Welds: A speed of travel along the joint edges which is too fast will cause the molten pool to decrease in size, resulting in a narrow weld. The reverse will be true if the speed of travel is too slow. A slow speed of travel usually causes excessive penetration of a rapid speed and inadequate amount of penetration.

Procedure for Welding Lap Joints

1. Set up work and tack weld, having sheets tightly together.
2. Preheat bottom sheet at point where weld is to be started.
3. Start at one end and complete weld, directing flame mostly on bottom sheet.
4. Add filler rod near top edge of joint building up bead to correct dimensions.
5. Turn work over and weld other side.
6. Cut welded joint out of specimen.
7. Check work with instructor after cutting.

Precautions: 1. Make sure that the surfaces of the two pieces to be welded fit closely together.

2. Make tack welds small and secure.

3. After tacking, check again to insure close fit of the two pieces.

BUTT JOINTS OF CARBON STEEL

OBJECTIVES

After completing this study guide and your classroom instruction, you will be able to apply the fundamental principles and techniques of welding butt joints.

INTRODUCTION

The butt joint is probably the most difficult joint to weld. The weld specifications must all be met to produce a joint that is as strong, if not stronger, than the base metal. The butt joint also withstands bending and twisting loads better than any other joint.

INFORMATION

The butt joint is used to join the ends or edges of two pieces of metal which are in the same plane. A properly made butt joint develops the full strength of the base metal and is satisfactory for all types of loads. The preparation of the joint for metals up to 1/8" thick requires matching of the sheets, spearated by a distance equal to the metal thickness. Regardless of metal thickness in any type of butt joint, the penetration through the base metal must be 100% and fusion into the sidewalls at least 1/16 of an inch. Care must be taken to space and tack the metal properly. Warping, insufficient penetration, or poor fusion, may result if proper spacing and tacking procedures are not observed.

Keep the plates on the same plane and maintain the correct spacing so that you can obtain the proper fusion and penetration. Make small, well penetrated tack welds so that the joint is held to a minimum of expansion on heating and a minimum of contraction or cooling. It is not necessary to preheat the plates but you should not overheat the molten pool. Overheating causes the molten pool to boil and spark excessively, enlarges the grain in the base metal next to the weld, lowers the strength of the weld, and causes scaling of the weld.

The height of reinforcement for metal up to 1/16" thick is approximately one T, or the thickness of the base metal. From 1/16" to 3/32", thickness the height of reinforcement drops to 75% of T. As the base metal thickness increases, the height of reinforcement decreases.

The width of reinforcement for metal up is approximately 2 to 4 T.

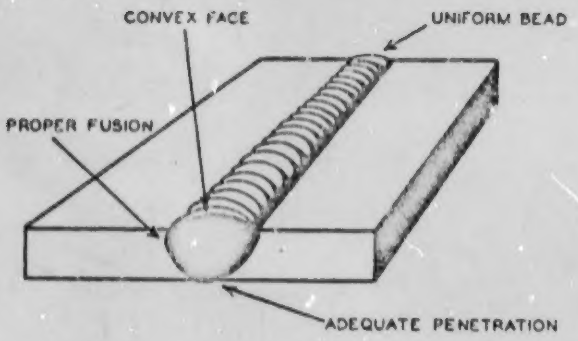

CONVEX FACE
UNIFORM BEAD
PROPER FUSION
ADEQUATE PENETRATION

Figure 63. Characteristics of a Good Butt Weld.

The reinforcement must have an even contour and taper gradually into the base metal at the toes of the weld, as shown in figure 63.

JOINT PREPARATION AND SETUP

Mill scale, rust, oxides, and other impurities should be removed from the joint edges and surfaces in order to prevent them from being included in the weld. Metal up to 1/8 inch thick can be welded without beveling.

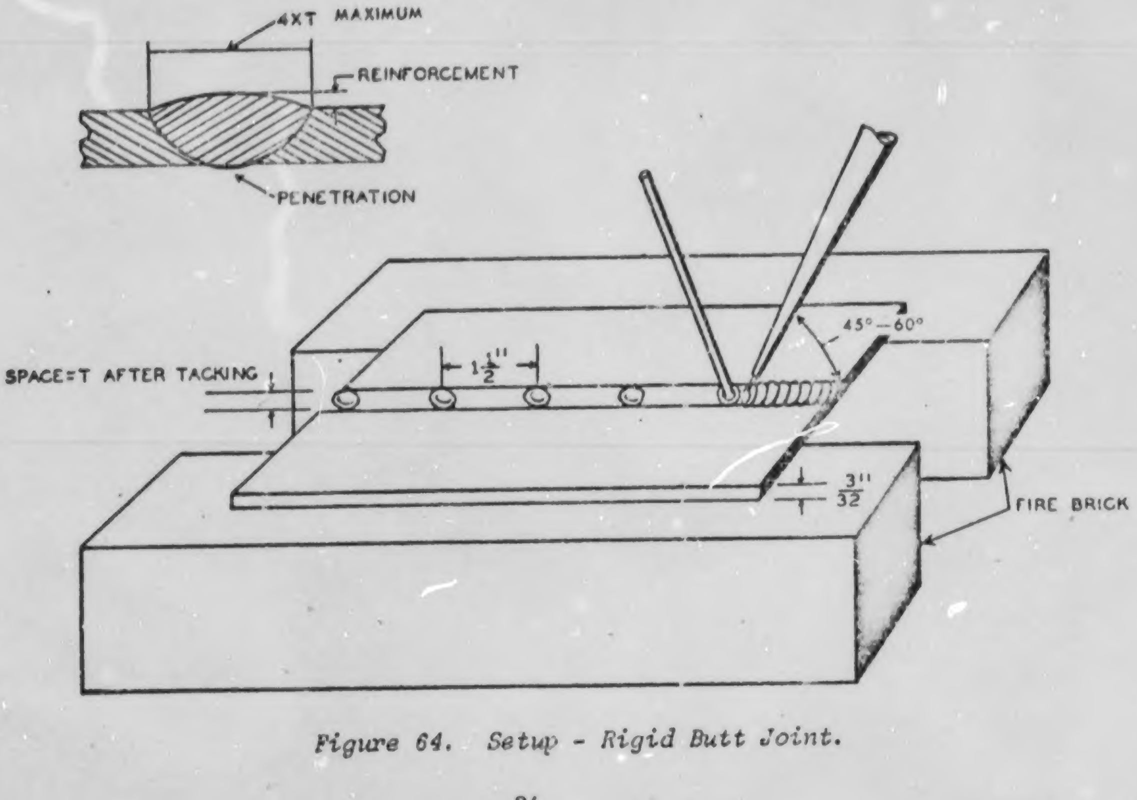

4XT MAXIMUM
REINFORCEMENT
PENETRATION
SPACE=T AFTER TACKING
$1\frac{1}{2}$"
45°—60°
$\frac{3}{32}$"
FIRE BRICK

Figure 64. Setup - Rigid Butt Joint.

Joint Setup

RIGID BUTT JOINT. Figure 64 shows the proper setup for welding a rigid butt joint in the flat position. The joint edges should be placed on the same plane and supported on material which does not radiate the heat away from the plate being welded. Rigid butt joints must be tack welded prior to welding to prevent the edges from being drawn together, making penetration impossible to obtain the amount of spacing for carbon steel is one "T". The importance of making good tack welds cannot be overemphasized. Proper spacing, size, and penetration of tack welds definitely helps to make a satisfactory weld. Penetration of the tack welds should be 100%. Tack welds not penetrating completely through the base metal causes weak spots in the finished weld. The tack welds should be rigid, yet small enough to permit easy fusion in welding. They should be spaced approximately one and one half inches apart along the joint.

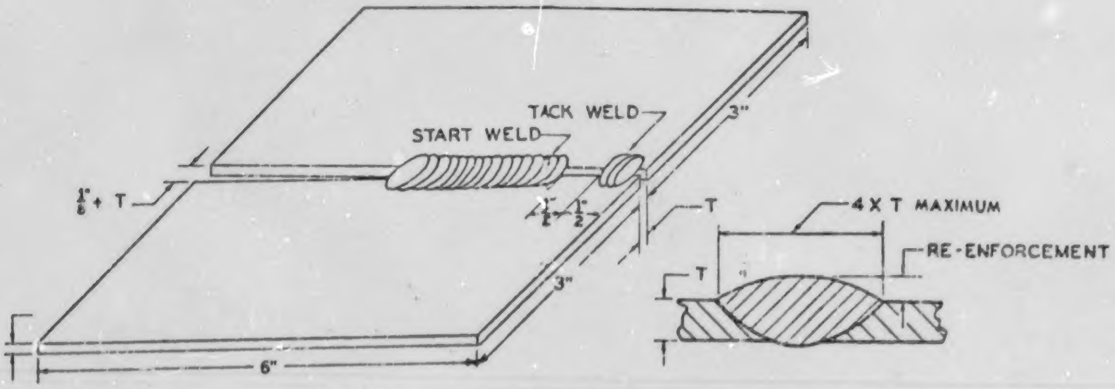


Figure 65. Open Butt Joint.

OPEN JOINTS. Joints not tacked prior to welding are drawn together as the weld progresses along the joint. The spot at which the first metal deposit is made is melted so rapidly that most of the expansion is taken care of in the molten pool. As the weld continues and the initial deposit cools, it contracts and pulls the two edges of the pieces together over their entire length before welding the far ends actually overlap before the weld is completed. One method of overcoming this effect is to setup the pieces as shown in figure 65. The spacing at the start of a carbon steel joint is one "T" while the open or finished end should be approximately 1/4 inch per foot of weld plus "T".

WELDING TECHNIQUE

Rigid Butt Joints

A good weld depends on the use of the proper tip size, filler rod, flame adjustment, and rod and torch manipulation.

The welding tip should form an angle of approximately 45° to 60° with the plate surface, with the flame being pointed in the direction of welding. Add the filler rod to the molten pool at an angle of about 45°. The motion of the flame should be controlled so that it melts the side walls of the sheets at the joint and enough of the filler rod to produce a molten pool of the correct size. The best technique for you depends upon the type of work you may be doing, but since any technique is based upon certain principles, you should learn them and follow them.

1. The molten pool should progress evenly down the seam.

2. The end of the filler rod should be dipped in the lending edge of the molten pool. Do not allow it to melt and drip into it.

3. Hold the inner cone of the welding flame approximately 1/16" above the molten pool. Do not allow it to touch the filler rod, molten pool, or the base metal.

4. The molten pool should penetrate completely through the joint but not extend too far below the bottom of the joint.

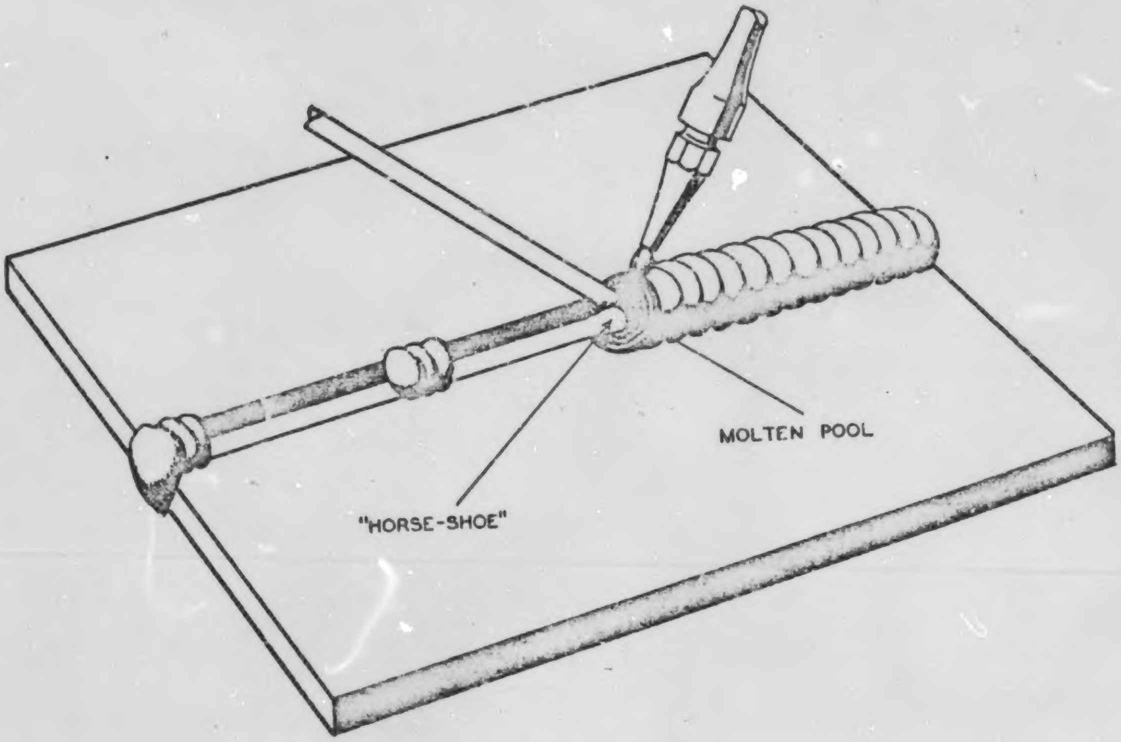


Figure 66. Rigid Butt Joint Welding Technique.

Figure 66 shows the technique which is used in welding rigid square edge butt joints. The edges of the metal are melted to the bottom of the joint causing the molten metal to form in the shape of a "horseshoe." The filler rod is added to the molten pool behind the opening and the molten pool bridges across the edges. The pressure and heat of the flame are used to reestablish the horseshoe opening. This procedure is repeated each time you add filler rod to the molten pool. By maintaining the horseshoe opening, penetration reaches completely to the bottom edge of the joint.

Open Butt Joints

The technique for welding open butt joints is the same as for rigid butt joints. In order to keep the joint from closing entirely, the starting end is spaced one T and the finishing end is spaced 1/4 inch per foot plus one T. The joint edges are tack welded as shown in figure 65 and the weld started immediately about 1/2 inch beyond the tack weld. As the weld progresses, the spacing gradually closes to a space equal to the base metal thickness.

PROCEDURES FOR WELDING BUTT JOINTS

Rigid Butt Joints

1. Clean the edges of the pieces to be welded.

2. Adjust the torch flame to neutral, and tack weld.

3. Start weld at the point indicated and weld by the forehand method toward the open end.

4. After completing this part of weld return to other end and finish the weld backhand.

5. If the plates get out of alignment, stop welding and force then back into position.

6. Before resuming welding, preheat the finished weld for about 1 1/2 inches back from point where the weld stopped.

7. Cool weld.

8. Check your work with the instructor.

Precautions:

1. Make sure that the sheets are in alignment after tacking.

2. Be sure the proper spacing is allowed.

3. Be sure that the tack is made and the weld is started at the exact point indicated on drawing.

Open Joints

1. Clean the edges of the metal.

2. Adjust the torch for a neutral flame, and tack weld.

3. Weld by the forehand method. Start at one end and weld to the other.

4. Melt the edges through to the underside and build up the bead to the proper dimensions.

Precautions:

1. Make tacks small and strong.

2. Be sure that metal is spaced properly before and after tacking.

3. Insure that the metal is on the same plane after tacking.

4. Be sure to use the correct tip size for metal welded.

TEE JOINTS OF CARBON STEEL

OBJECTIVES

After completing this study guide and your classroom instruction, you will be able to apply the fundamental principles and techniques of welding tee joints of carbon steel in the flat position.

INTRODUCTION

The tee joint is used quite often in construction of ships, storage tanks, and as reinforcement for other welding operations. The principles involved are closely related to the lap joint. The major difference between a lap weld and a tee weld is the height of the upper leg of the weld and the weld face contour. The biggest advantage of a tee weld is its ability to be built up in more than one layer so that it can obtain the maximum amount of strength for the joint.

INFORMATION

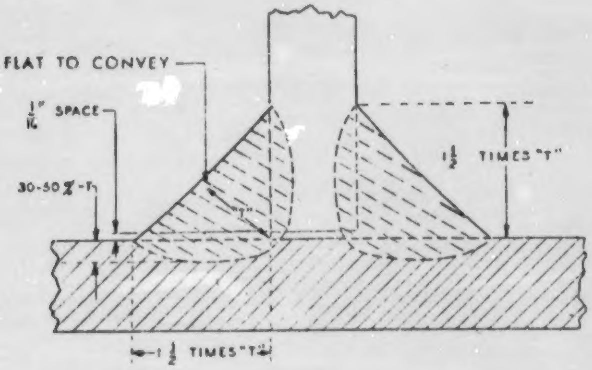


Figure 67. Throat and Leg Dimensions.

A tee joint is formed when the edge of one plate is welded approximately perpendicular to the surface of another. The weld is called a fillet weld because it is triangular in cross section. The various sections of a tee joint are shown in figure 66. The terms used to identify the weld sections are the same for all types of joints. Specifications for the tee joint are shown in figure 67. When both pieces of the base metal are the same thickness, the upper and lower leg specification should be 1 1/2 T. If one piece is thinner than the other, the thinner piece determines the leg length or heigth. Penetration should be from 30 to 50 percent for metal 1/8" thick or less. For metal

metal over 1/8", thick the penetration should be at least 1/16". The throat thickness should be "T".

PREPARATION AND WELDING OF TEE JOINTS

Joint Preparation

The tee joint used on metal 1/8" thick or less needs no special preparation other than cleaning the edge of the vertical sheet and the surface of the horizontal sheet. On metal over 1/8", the vertical sheet should be beveled. The single V-45° bevel is used on metal up to 1/2". The double V-45° bevel is used on plate 1/2" or thicker if it can be welded from both sides. If heavy plate cannot be welded from both sides, the bevel used is a single U which allows for complete penetration without an excessive amount of filler material or manhours which would be needed if the single V were used.

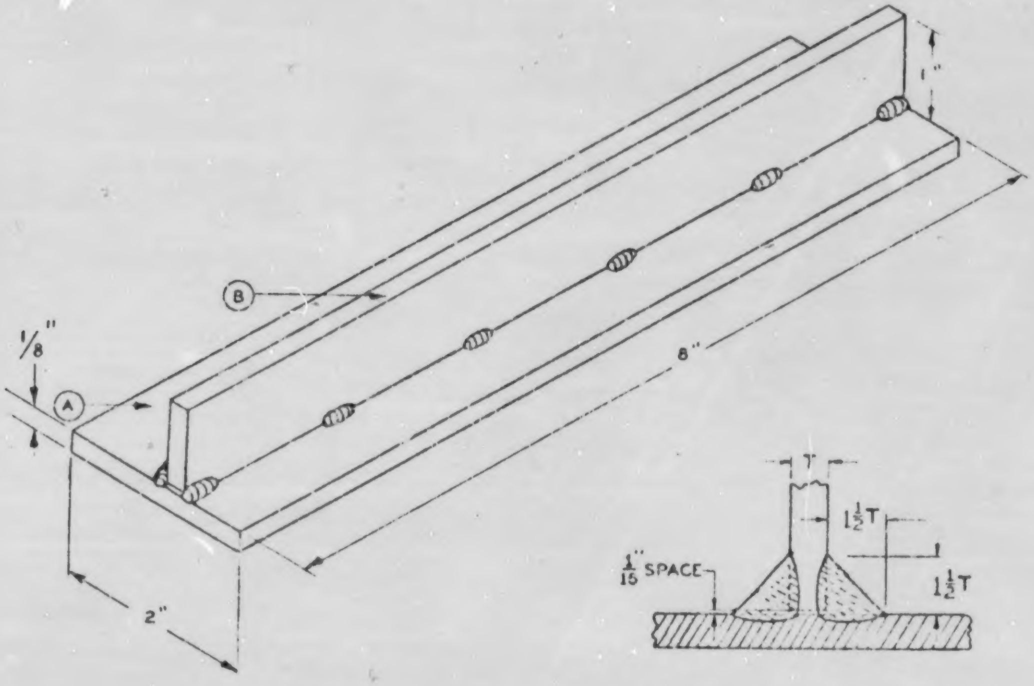


Figure 68. Setup of Tee Joint.

The vertical sheet, figure 68, should be spaced from 1/32 to 1/16 of an inch above the horizontal sheet. The welding heat cannot be used to its greatest advantage unless the edges are spaced to permit easy fusion without excessive heating. The spacing should be the same along the joint so that penetration and fusion can be obtained. When the joint is welded on both sides, the tack welds should be made alternately from one side to the other. Tack welding in this manner aids in maintaining alignment of the vertical sheet. If welding only one side, tack weld one side.

Welding Technique

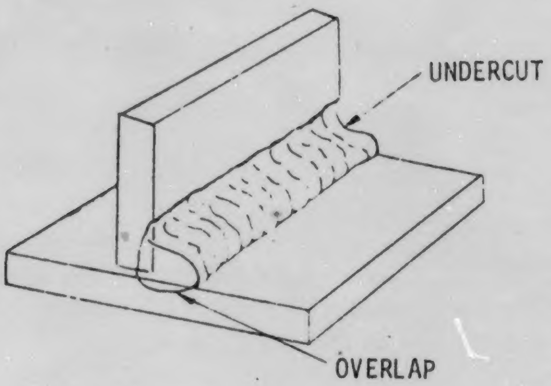


Figure 69. Tee Joint - Overlap and Undercut.

Select the proper tip size and adjust the flame to neutral; then, holding the torch at a 45° to 60° angle, direct most of the heat on the bottom plate. When the molten pool forms, be sure that it extends equally on both plates. To prevent undercutting, figure 69, the filler rod should be added to the upper edge of the molten pool.

PROCEDURE

1. Clean the metal to be welded.

2. Set up the joint, as shown in figure 68, and tack weld at approximately two-inch intervals; allow 1/16" spacing, figure 67.

3. Start at one end and complete the weld.

4. Weld by the forehand method, taking care to direct most of the flame on the bottom sheet.

5. Check with the instructor for weld faults.

6. Repeat the above procedure until you can make satisfactory tee welds.

Precautions: 1. Make sure that the vertical piece is securely tacked to the horizontal piece with small tack welds.

2. Make sure that the proper size tip with sufficient volume of heat is used.

3. Make sure that the penetration is extending into the root of the joint as the weld progresses.

Metallurgy Branch
Chanute AFB, Illinois

POSITION WELDING

OBJECTIVES

After completing this study guide and your classroom instruction, you will be able to apply the technique of welding joints in the horizontal and vertical positions.

INTRODUCTION

Although the different types of joints are easily welded in the flat position, these joints are not always found in this position. Many times you may be required to weld a joint in one of the other positions. In order to successfully weld a joint in the horizontal or vertical position, you must know and apply the techniques required to allow the weld to meet the specifications for the type of joint.

INFORMATION

All welding can be classified according to the position of the metal or joint edges of the metal being welded. There are four general positions in which welds are required to be made. These are designated as flat, horizontal, vertical, and overhead positions.

In the flat position the weld is made with the parts flat on the table or inclined at an angle less than 45 degrees, the filler metal is deposited from the upper side of the joint, and the face of the weld is approximately horizontal.

In the horizontal position the weld is made with the parts in a vertical position or inclined at an angle of more than 45 degrees with the seam running horizontally.

In the vertical position the parts are inclined at an angle greater than 45 degrees with the seam running vertically.

In the overhead position the filler metal is deposited from the underside of the joint and the face of the weld is approximately horizontal.

WELDING IN THE HORIZONTAL AND VERTICAL POSITIONS

In order to make satisfactory welds in positions other than flat, a knowledge of factors which permit control of the weld metal in these various positions is essential. Due to the effect of gravity, the molten weld metal in the puddle always tends to seek a lower level. This tendency is restrained by the following forces: cohesion of the molten pool; support provided by the base metal and solidified weld metal; pressure of the flame on the molten metal; the manipulation and chilling effect of the filler rod upon the molten pool; and surface tension.

The most important force counteracting the force of gravity is the cohesiveness of the molten metal, which allows a certain amount of molten metal to be placed in the molten pool without running or falling off. A factor affecting cohesion is the amount of heat applied. More heat than necessary increases the fluidity of the molten metal, resulting in a greater tendency of the metal to run or fall off.

Horizontal Welding

When you weld joints with the joint edges horizontal, the tip should be held at an angle of 45 degrees to the plate surface and inclined slightly in the vertical plane, to direct the flame upward. The slight inclination given to the tip keeps the molten metal from sagging to the lower edge of the weld. The tip should be moved slightly from side to side to deposit the metal uniformly along the joint. The filler rod added to the upper edge of the molten pool permits an even distribution of weld metal.

Vertical Welding

In vertical welding the molten metal has a tendency to run down, due to the force of gravity, and cause a highly-crowned bead. To control the flow of molten metal, the flame should be held below the welding rod. pointing upward at an angle of 45 degrees to the plate. The pressure of the gases from the tip help support the molten metal; however, removing the flame momentarily when the molten metal tends to sag will aid in producing a weld of proper contour. The solidified weld metal just below the molten pool acts as a ledge and provides additional support.

PROCEDURES

Double-Fillet Lap Joint

1. Clean the metal to be welded.

2. Lap 1/2 inch and tack weld in the flat position on the bench.

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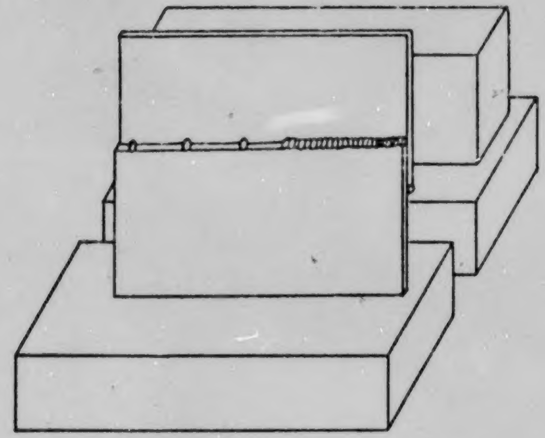

Figure 70. Horizontal Lap Joint.

3. Mount in the horizontal position, as shown in figure 70, and weld in the fixed horizontal position.

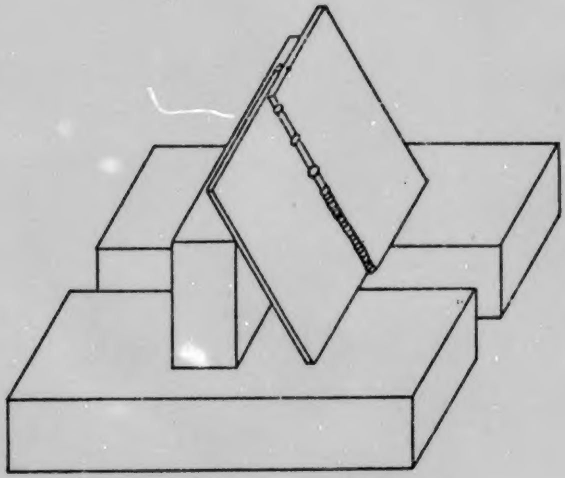

Figure 71. Vertical Lap Joint.

4. Mount in the vertical position, as shown in figure 71, and weld in the fixed position.

Vertical Tee Weld

1. Clean the metal to be welded.

2. Space the tack weld in the flat position on the bench.

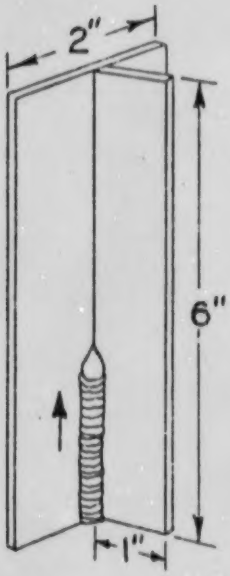

Figure 72. Vertical Fillet.

3. Mount in the vertical position, as shown in figure 72, and weld.

Technical Training

Metals Processing Specialist

BLOCK II
OXYACETYLENE WELDING, CUTTING, SOLDERING, BRAZING AND HARD SURFACING

13 June 1975

13-5

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR53230-SG-200, 11 December 1972.
OPR: TWS
DISTRIBUTION: X
TWSTC - 250; TTVGC - 2

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Metal and NDI Branch
Chanute AFB, Illinois

3ABR53131-SG-201

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MECHANICAL DRAWING AND BLUEPRINT READING

OBJECTIVES

After completing this study guide and classroom instruction, you will make shop drawings and sketches of welded assemblies and interpret shop drawings, diagrams, and blueprints.

INTRODUCTION

Nearly every repair or fabrication job you will do will require working to specifications contained in a drawing or a blueprint. At times, you will be required to make your own sketches and drawings to design parts for which there are no drawings or blueprints. Interpreting blueprints and drawings is a skill you must learn to qualify as a metals processing specialist.

INFORMATION

MANAGEMENT OF DEFENSE ENERGY AND RESOURCES

Due to the conservation of energy resources, do not write in or mark on any training literature since it will be reused by other classes. Lights will be turned off any time the classroom is vacant for more than 20 minutes. All consumable materials will be used conservatively throughout Block II.

DRAWING EQUIPMENT AND GEOMETRIC CONSTRUCTION

This study guide covers drawing equipment, the use of geometric construction principles in making a blueprint or drawings and the interpretation of blueprints and drawings.

The purpose of a drawing is to indicate the form and size of an object and to convey the ideas of the engineer or designer to the person who is to use the drawing. The form of the object is indicated on the paper by the relative positions of lines. It is more efficient to show the various design features in the form of a drawing. In this way the details of construction can easily be understood. A written or verbal description of detailed parts would be too extensive and would only confuse the workman. A drawing showing dimensions and explanatory notes gives the workman clear, easily interpreted information. Drawings are made with the aid of various instruments and equipment. If the drawing is made with instruments, it is a mechanical drawing; whereas, if it is made with only a pencil, it is a free-hand sketch.

Drawing Equipment

The following paragraphs explain the various tools and equipment used in making drawings.

DRAWING BOARD, T-SQUARE, AND TRIANGLE. A drawing board may be used to provide a flat, smooth surface for the paper while the drawing is being made. The left edge of the board is used as a straightedge to guide the T-square. The blade of the T-square provides a straightedge for triangles.

DRAWING PAPER. Drawing paper is available in a variety of grades. It may come in sheets or rolls and be colored white, cream, or buff. For pencil drawings, such as those made in the shop, paper with a slight grain that can be easily erased is best. Tracing paper is used to make original drawings because it is transparent enough so that original drawings may be traced or inked. The drawing paper is placed near the edge of the board and the upper edge of the paper is lined parallel to the T-square. After the paper is in place, it is taped down at the corners, as shown in figure 1. Occasionally, thumbtacks are used to hold the paper but they are not as suitable as tape.

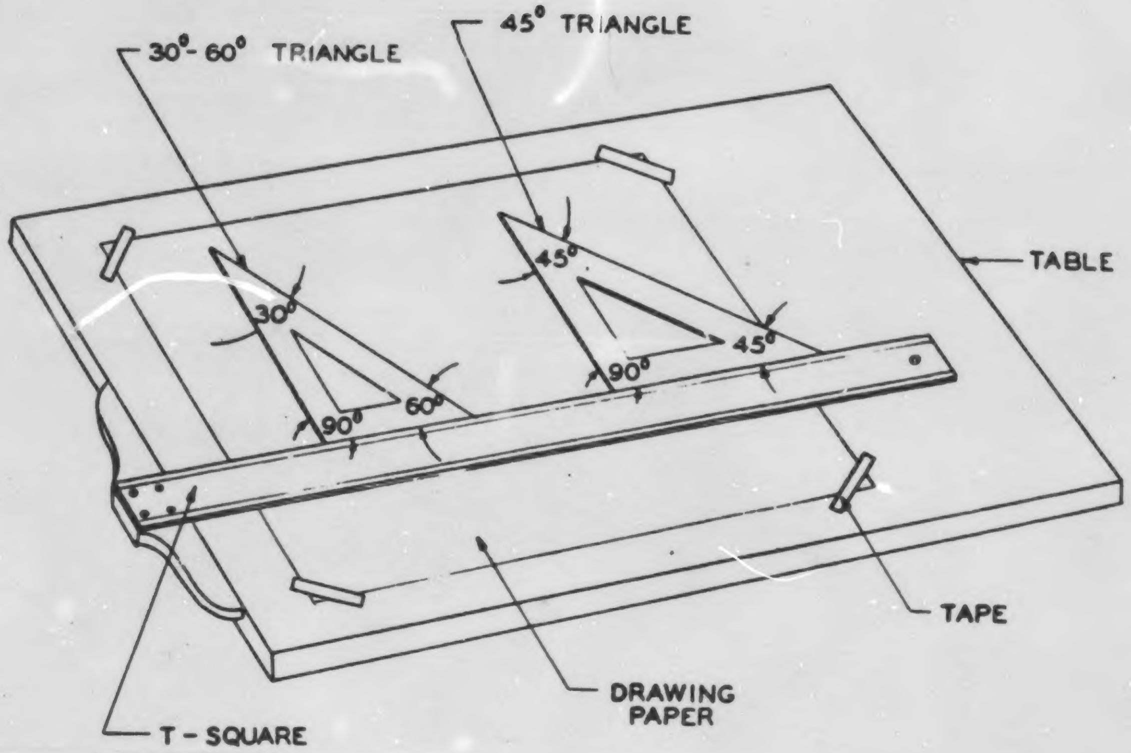


Figure 1. Drawing Board Setup.

DRAWING PENCILS. Pencils are graded by letters from 6B (softest) through 5B, 4B, 3B, 2B, B and HB (medium soft), F (medium hard), H, 2H, 3H. 4H, 5H, 6H, 7H, 8H, 9H (extremely hard). Grades 4H and 6H are generally used for drawing lines while grades F, H, and 2H are preferred for lettering and sketching.

T-SQUARE. This drawing ruler, shown in figure 1, is a T-shaped instrument consisting of a straightedge with a head at one end. The head is fastened to the straightedge at a right angle to the blade with screws. It is used as a guide for horizontal, vertical, and sloping lines.

TRIANGLES. These instruments are used to draw vertical and sloping lines. The two most commonly used triangles are the 45° and the 30°/60° triangles. The former has two angles, 45° and 90°. The latter has 30°, 60°, and 90° angles. Generally, they are made of plastic. Various angles can be obtained when they are used with the T-square, as shown in figure 2.

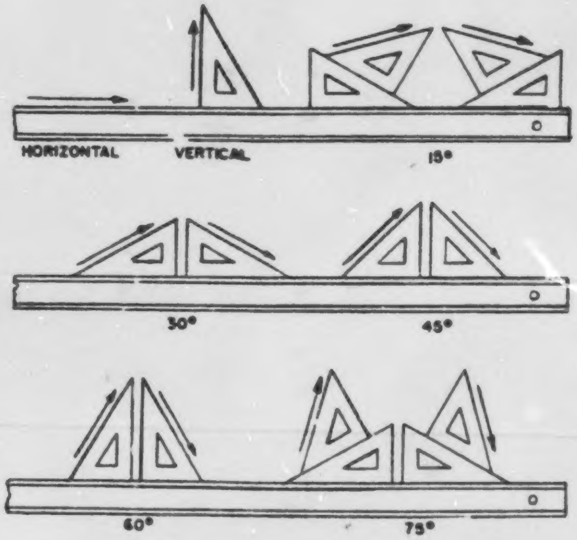


Figure 2. Application of a T-Square and Triangle.

PROTRACTOR. This instrument is used for drawing angles that are not

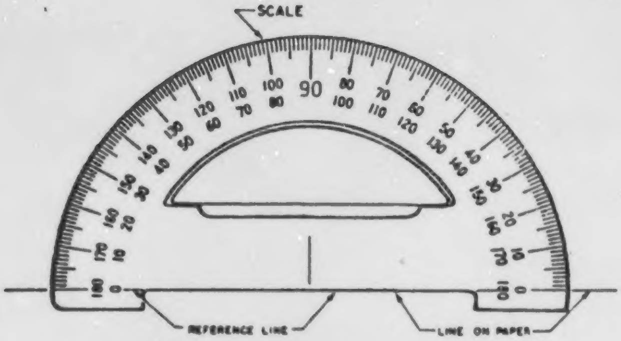


Figure 3. Protractor.

included in regular triangles. Protractors are usually graduated from 0° to 180° in divisions of 1°, as shown in figure 3. Protractors are also available with smaller divisions. The protractor is placed with its reference line over the line of the paper and its center mark at the point where the angle is to be drawn. Mark the center point. The desired angle can then be found on the outer edge of the protractor. Mark the paper at the desired angle. Remove the protractor and draw a straight line from the point just marked to the center point of the protractor. Thus, the required angle is made.

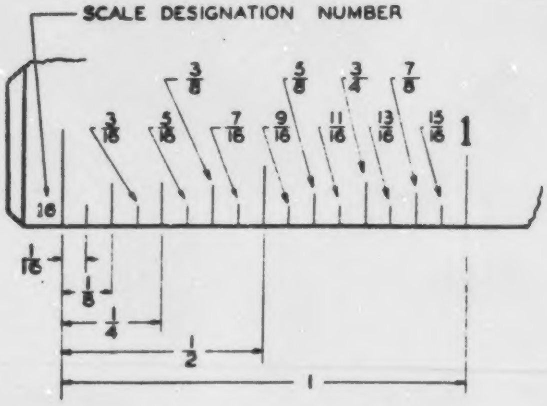


Figure 4. Scale.

SCALES. Two shapes of scales are commonly used; the flat, and the triangular. They are usually made of boxwood; although some are made of hardwood. In the past years, plastic has been used extensively in the manufacture of scales. There are two types of triangular scale; the engineer's and the architect's. The engineer's scale has inch divisions subdivided into decimals of an inch. The architect's scale is generally used in the preparation of drawings. The scale is intended only for measuring and should not be used as a straightedge. The scale has eleven sets of graduations or scales. At each end of the scale, except the full size scale, is a number (usually a fraction) showing the size or breakdown of the scale. On the left end of the full size scale, the number 16 appears. This indicates that the full scale is divided into 16ths of an inch units. This is the scale that will concern the beginner in mechanical drawing the most. The full size scale is used for drawings of the same size as the object or the parts they describe. Figure 4 shows how each division is read as a fraction when a full size scale is broken down in 16ths. An explanation of the rest of the graduations on the architect's scale will be given by the instructor.

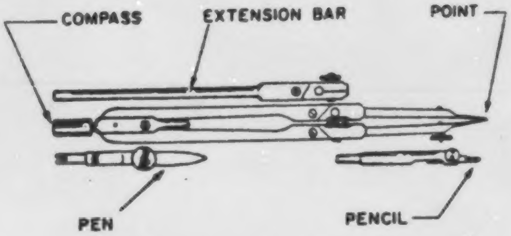


Figure 5. Compass.

COMPASS. The compass, shown in figure 5, is an instrument that is used for drawing circles or parts of a circle. The compass consists of two legs hinged at the top to permit adjustment to the desired spread. One leg is designed so that a pencil or pen can be used. Usually, an extension bar is included for a greater spread.

Geometric Construction

Drawings are used to express and record the ideas and information necessary for the building of machines, structures, and parts that make up a complete object. In the making of drawings, the draftsman may use geometric principles to resolve various drawing problems rapidly and accurately. The welder will also use drawings as a guide in the fabrication of parts. The welder must have a knowledge of geometric constructions in order to understand drawings, since drawings are lines, circles, arcs, and curves; it will be necessary to learn the general methods of drawing each of them.

Figure 6. Angle.

DRAWING AN ANGLE. An angle is formed by drawing two straight lines that intersect. These lines must meet at one point, as shown in figure 6. Angles can be drawn very rapidly with the use of a triangle.

Figure 7. Circle.

DRAWING CIRCLES. A circle is a line drawn with a compass from one central point, as shown in figure 7. The distance from the line to the center point remains the same. Any straight line from the center point to the line is called the RADIUS of the circle. A straight line passing through the center, which cuts the circle into two equal halves is called the diameter of the circle. The diameter is equal to twice the radius ($d = 2r$).

To draw a circle with a pencil compass or divider, set the radius and swing a circular line around a center point. To avoid changing the radius, do not move or hold the legs of the compass while the circle is being drawn.

Figure 8. Arc.

DRAWING AN ARC. An arc is part of a circle and is drawn in the same manner as a circle, as shown in figure 8

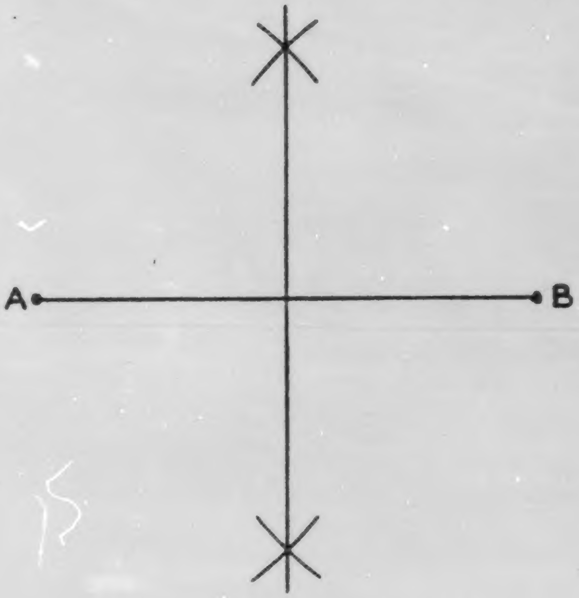


Figure 9. Bisecting a Line.

BISECTING A LINE. Bisecting a line means to divide it into two equal parts. This is done with the use of a pencil compass or divider. Set the compass or divider at a distance greater than half the length of the line. Set the needle point on one end of the line, point of A, figure 9, and draw an arc above and below the line. Using the same setting, place the needle point on the other end of the line, point B and cross the first two arcs above and below the line, points C and D. Draw a thin line through the points where the arcs intersect. The thin line will bisect line AB.

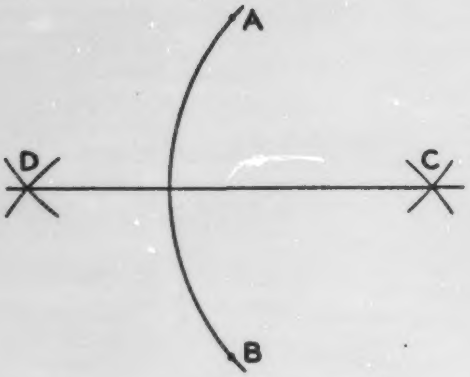


Figure 10. Bisecting an Arc.

BISECTING AN ARC. Bisecting an arc is similar to bisecting a line. Set the pencil compass or divider at a distance greater than half the length of the arc. Set the needle point on one end of the arc, point A on figure 10, and draw an arc on each side of the original arc. Using the same setting, place the needle point on the other end of the original arc, point B and cross the first two arcs at C and D. Draw a thin line through the points where the arcs intersect. The thin line bisects arc AB.

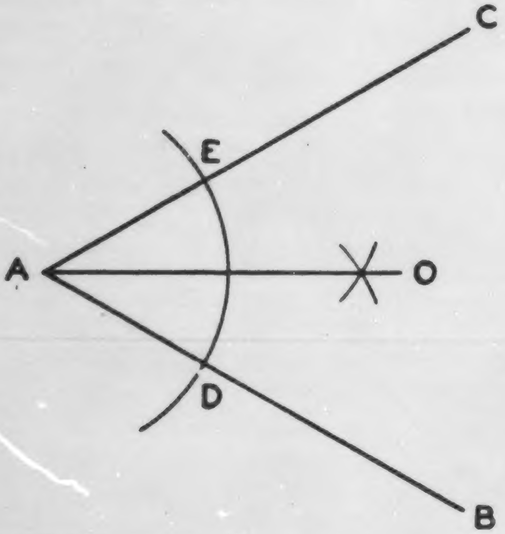


Figure 11. Bisecting an Angle.

BISECTING AN ANGLE. To bisect the angle BAC, figure 11, use A as a center and strike an arc DE. With D and E as centers and a radius greater than one-half DE, draw small arcs intersecting at O. Line AO bisects the angle BAC.

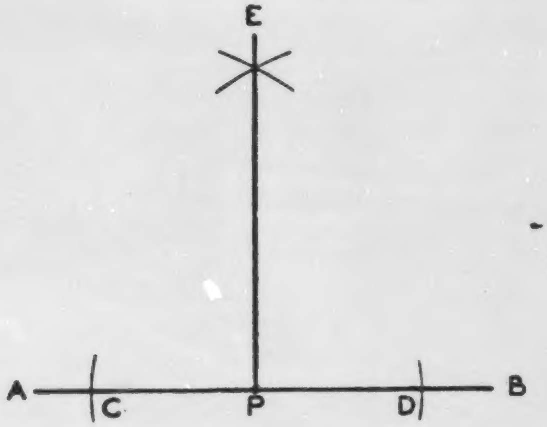


Figure 12. Erecting a Perpendicular to a Given Line From a Point on the Line.

DRAWING PERPENDICULAR TO A STRAIGHT LINE. A perpendicular is a straight line that meets another straight line at 90°. To draw a perpendicular to a line from point P on that line (figure 12), with P as a center and with any radius, draw arcs intersecting the line at C and D. Then, with C and D as centers and a radius longer than one-half the distance between C and D, draw arcs intersecting at E. Line EP is the required perpendicular.

To draw a perpendicular to a line AB (figure 13) from a point P some distance away from the line: With point P as center, draw an arc intersecting the line at C and D. With C and D as centers, draw arcs with a radius longer than one-half C and D. These arcs intersect at E. Line EP is the required perpendicular.

DRAWING A LINE PARALLEL TO ANOTHER LINE. To draw a line parallel to line AB (figure 14) at some distance away from the line, with any points 1 and 2 as centers on line AB, draw arcs with the desired distance as

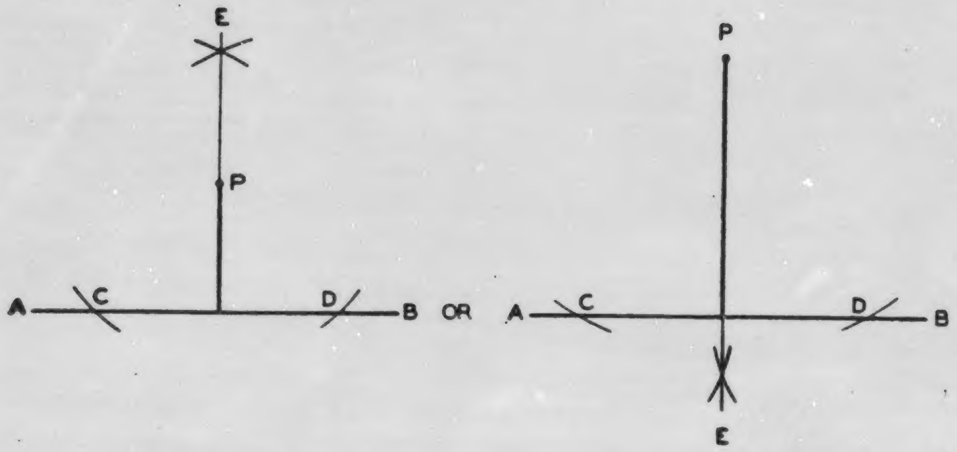


Figure 13. Erecting a Line Perpendicular to a Given Line Outside the Line.

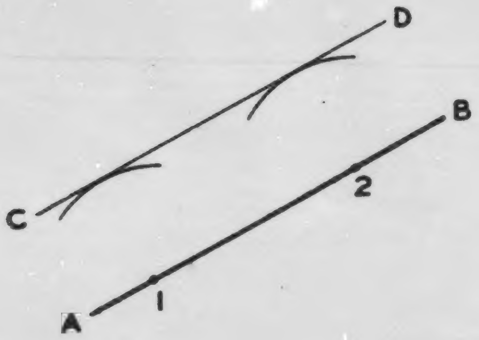


Figure 14. Constructing a Line Parallel to Another Line.

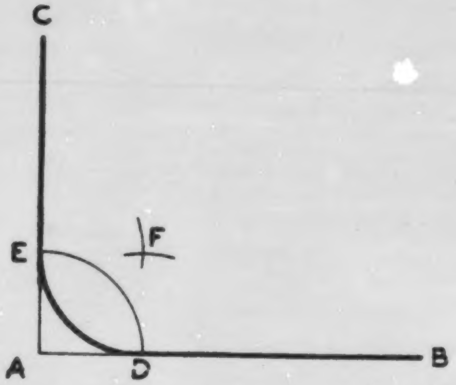


Figure 15. Drawing an Arc Within a Right Angle.

radii. Line CD, drawn tangent to the arcs, is the required parallel line.

DRAWING AN ARC WITHIN A 90° (RIGHT) ANGLE. To draw an arc within a right angle, figure 15, with A as a center and with any desired radius, draw arcs across lines AB and AC establishing points D and E. Using the same radius and with D and E as centers, draw intersecting arcs to form point F. With F as center, draw the required arc from points D and E, as shown in figure 15.

CONSTRUCTING AN ARC TANGENT TO INTERSECTING LINES. Select points 1 and 2 on line AB and points 3 and 4 on line BC, as shown in figure 16. Set a small pencil compass at the desired radius and strike an arc from points 1, 2, 3, and 4 on the same side of lines AB and BC. Using a triangle as a straightedge, draw lines DE and EF tangent to the arcs. With the same compass setting, place the needle point of the compass at point E (the point of intersection of the two constructed

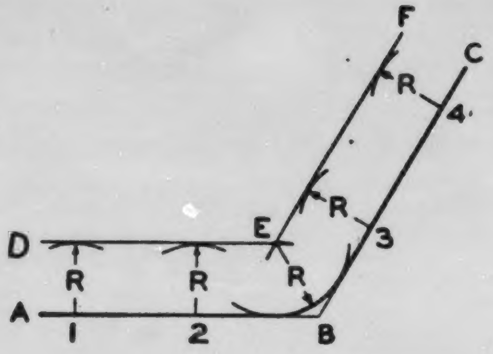


Figure 16. Constructing an Arc Tangent to Intersecting Lines.

lines) and strike an arc tangent to lines AB and BC.

DRAWING A 60° ANGLE. To draw a 60° angle from a point on a line (figure 17) with A as a center and any radius, draw arc BC. With point B as a center and the same radius AB, draw an arc intersecting at point E on the arc just drawn. EAB is a 60° angle.

Note: A 30° angle may be obtained by bisecting the 60° angle.

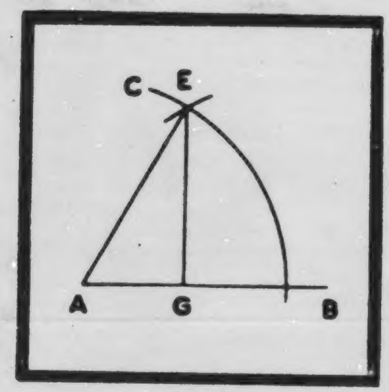


Figure 17. Drawing a 60° Angle.

DRAWING A 45° ANGLE. To draw a 45° angle from a point on a line (figure 18), from point A on line AB, set off a distance AC. Draw the perpendicular DC, and set off a distance CE equal to AC. Draw AE; angle EAC is a 45° angle.

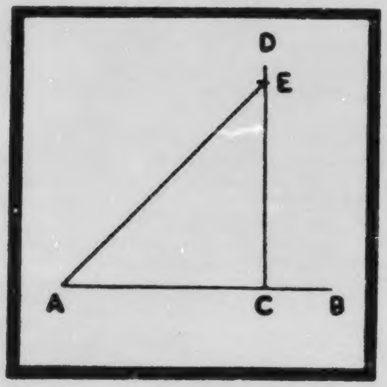


Figure 18. Drawing a 45° Angle.

DRAWING A RIGHT ANGLE. A right angle is an angle of 90° formed by two intersecting perpendicular lines.

When several lines, arcs, and circles are found on one drawing, letters and/or numbers are used to identify specific places or parts on the drawing.

Your duties will require making layouts on paper and metal for required repairs. Layouts include lines, circles, and arcs.

DRAWING A STATION JOINT. Using geometric construction, make a shop drawing of a station joint to scale, using the dimensions given in figure 19.

QUESTIONS

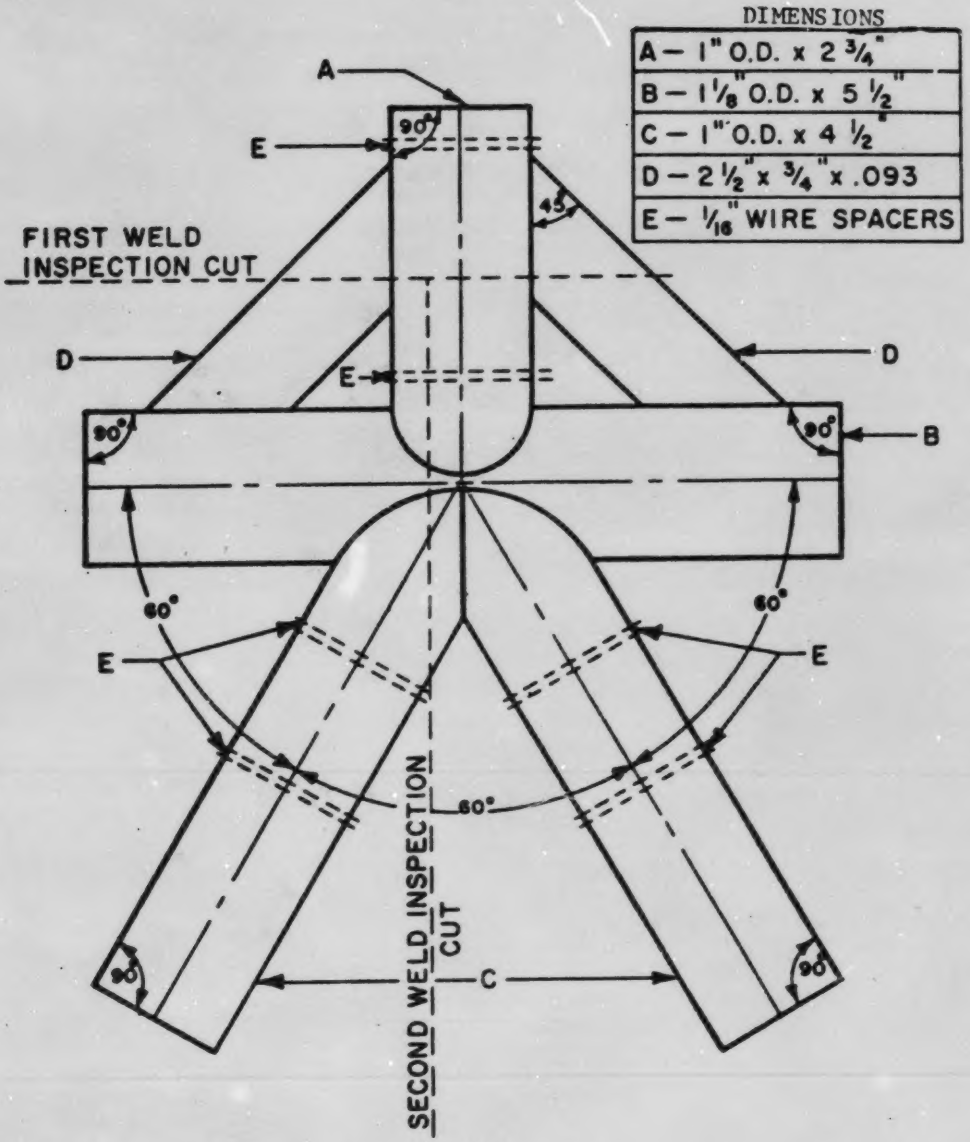
Note: Do not write in this study guide. Answer all questions on a separate sheet of paper.

1. Why is it necessary for a metals processing specialist to know how to draw?

2. How many degrees are in a circle?

3. What is a radius?

4. Define the diameter of a circle.


A
E
90°
45°
FIRST WELD INSPECTION CUT
D
E
D
90°
90°
B
60°
60°
E
E
60°
SECOND WELD INSPECTION CUT
90°
C
90°

DIMENSIONS

A — 1" O.D. x 2 3/4"	
B — 1 1/8" O.D. x 5 1/2"	
C — 1" O.D. x 4 1/2"	
D — 2 1/2" x 3/4" x .093	
E — 1/16" WIRE SPACERS	

1. Layout centerlines.
2. Draw tube B.
3. Draw tube A.
4. Draw tube C.
5. Draw gusset plates.
6. Draw wire spacers (E).

Figure 19. Station Joint.

5. What is an arc?

6. What does bisect mean?

7. What is a perpendicular line?

8. What are parallel lines?

9. A 60° angle is what part of a circle? A 30° angle? A 45° angle?

10. What is a right angle?

TYPES OF DRAWINGS

The most common type of drawing is the orthographic. Although they are used much less frequently than the orthographic, there are times when an isometric, perspective, or oblique drawing is useful. The four types of drawings are as follows:

Orthographic Drawing

An orthographic drawing is a way of representing the exact shape of an object in views. Each of these views show the shape of the object from the front, top, side, etc. Any two or more views will completely describe the object. Each view is a completed picture of the surface of the object which it represents.

To understand the orthographic drawing, consider that each edge of the object is represented by a line. Each line will be seen in its true length and in its proper place as it appears in the object. A good way to visualize this is to imagine the object suspended in the center of a transparent box with its sides parallel to those of the box, as shown in figure 20. Looking in each side of the box, you will see different views of the object. If these views were projected to the surfaces of the transparent sides of the box, as in figure 21, and if the box were flattened out, as in figure 22, we would have an orthographic drawing.

If lines could be extended from every point, edge, and surface of the object to the transparent box, the result on the front of the box would be the front view and would show the true height and length of the object.

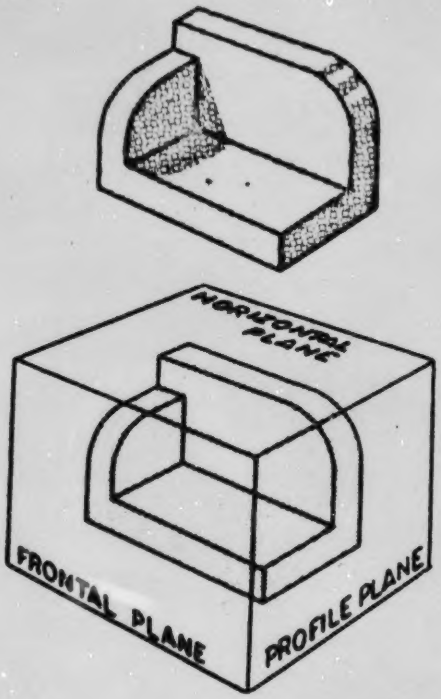


Figure 20. Visualizing an Orthographic Drawing.

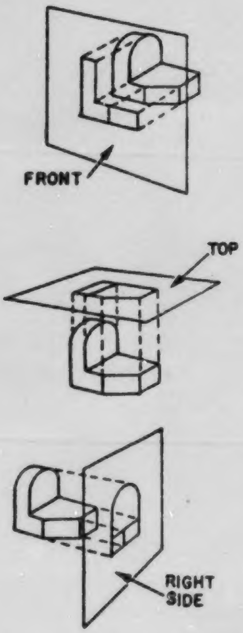


Figure 21. Projections.

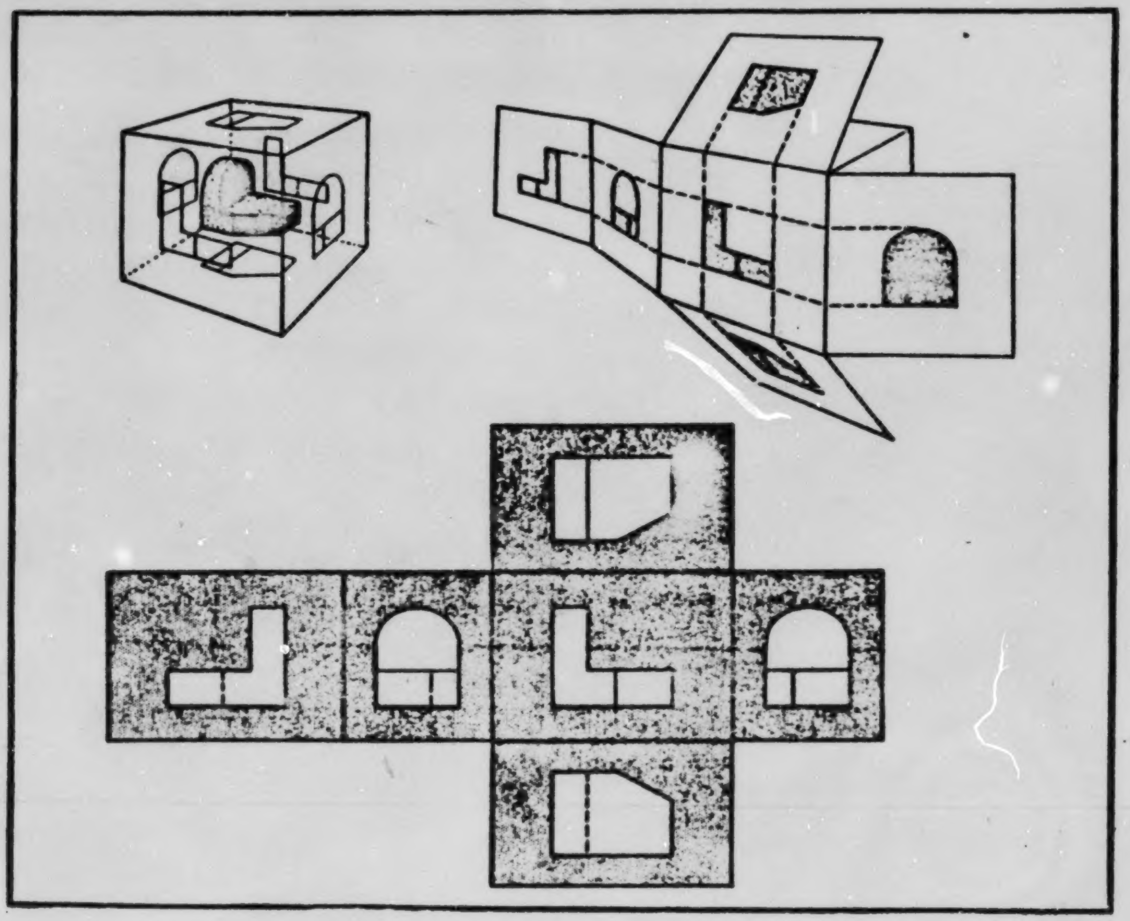


Figure 22. Orthographic Views in Position.

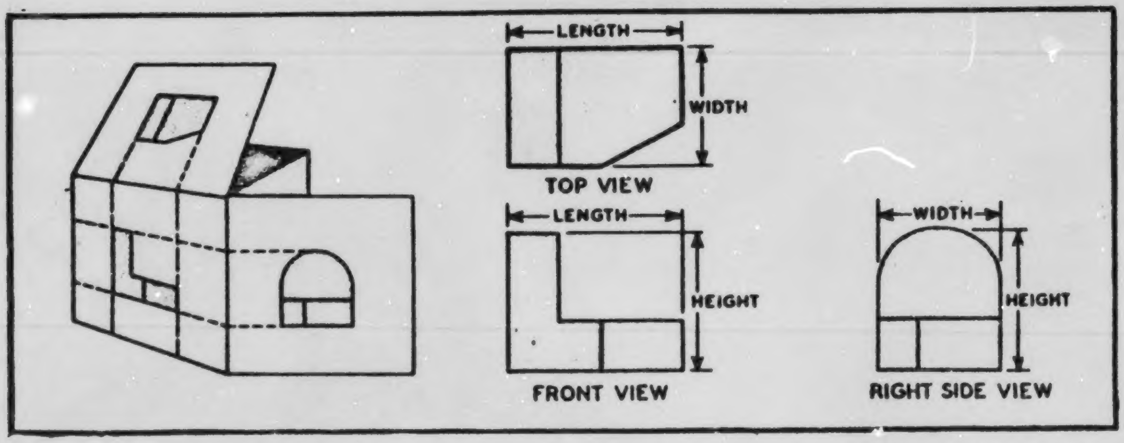

LENGTH
WIDTH
TOP VIEW
LENGTH
HEIGHT
FRONT VIEW
WIDTH
HEIGHT
RIGHT SIDE VIEW

Figure 23. Three-View Projection of Length, Width, and Height.

Lines from the object to the top of the box give the top view and show the true width and length of the object. Lines from the object to the right side of the box give the side view and show the true height and width of the object, as shown in figure 23.

> Note: Since there are six sides to the box, there will be six basic views. However, two or three views are all that are necessary to visualize the object.

Usually, the orthographic drawing of a given object is started by drawing the front view. The top view is drawn directly above the front view with the aid of vertical lines extended from the front view.

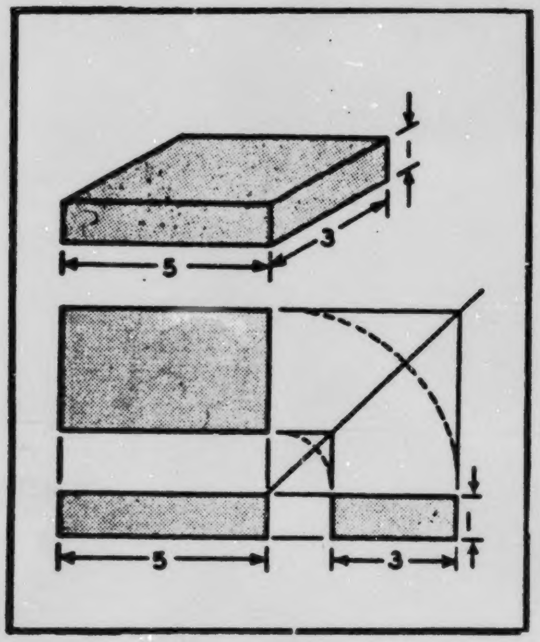


Figure 24. Drawing an Orthographic Projection.

The side view of the object is drawn to the right of the front view by the aid of horizontal lines extended from the front view and by projected lines drawn from the top view, as shown in figure 24.

Since it is necessary to describe every part of an object, all surfaces must be represented even if they cannot be seen. To identify surfaces which

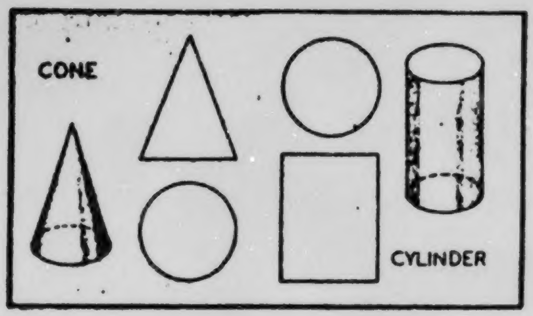


Figure 25. Views Necessary for Cylinders and Cones.

Curved surfaces such as cones and cylinders are seen as circles, triangles, and rectangles in the views. A cylinder may appear as a circle in one view and as a rectangle in another view, as shown in figure 25.

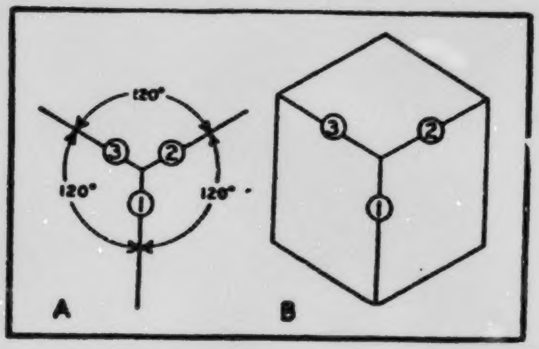


Figure 26. Isometric Axes.

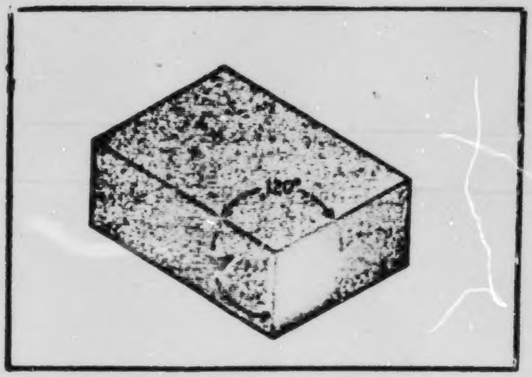


Figure 27. Isometric Drawing.

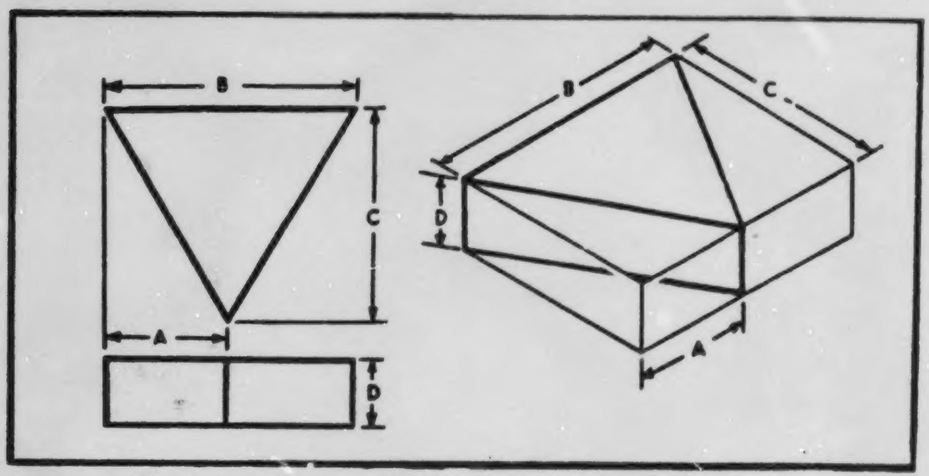


Figure 28. Representing Angles on Isometric Drawings.

Isometric Drawings

Isometric drawings are pictorial views of objects. They are built on three lines representing three edges of a cube, such as lines 1, 2, and 3 in figure 26. These three lines form three angles of 120° and are called isometric axes (figure 26A). One is drawn vertically and the other two at 30° angles from the horizontal by using a 30°/60° triangle and T-square.

The dimensions of the block (length, width, and height), are laid off in true length on the isometric axes and lines are drawn through those parallel to each axis (figure 27). Any line of the object that falls on, or is parallel to, the isometric axes is called an isometric line.

Edges of an object not falling parallel to one of the isometric axes are called nonisometric lines. Nonisometric lines must be constructed by joining their two terminal points with the aid of a straight edge (figure 28). When an object contains many nonisometric lines, it is easiest drawn if you visualize it being placed in a box. The box is then drawn in isometric and the object located in it by its point of contact, as in figure 28.

Perspective Drawing

A drawing that shows the shape of an object just as it appears to the eye of the observer is called a perspective drawing, figure 29. An accurate copy of a photograph of an object would be a drawing that is in true perspective. This is because a camera records an object the way the eye sees it. A perspective drawing of a piece of work has its value; however, it is of little help to a welder. It only shows the picture of the object and indicates the shape as viewed from one position. It gives no detail as to the internal construction, which is what you need to know. Perspective drawings are used very little in welding work but they may accompany mechanical drawings for the purpose of showing an overall picture of the finished product.

Oblique Drawing

An oblique drawing is based on the theory that one face of the object is parallel to the picture plane. Oblique drawings are similar to isometric drawings in that they are based on three axes on which measurements may be made. In an isometric drawing, the axes are placed at 120° to each other. In oblique drawings, two axes are always at a right angle to each other and the cross axes may be at any convenient angle, as in figure 30A.

Oblique drawings have an advantage over isometric drawings in that an object with a circular outline on each face may be represented in true form. Also, any object with an irregular outline can be

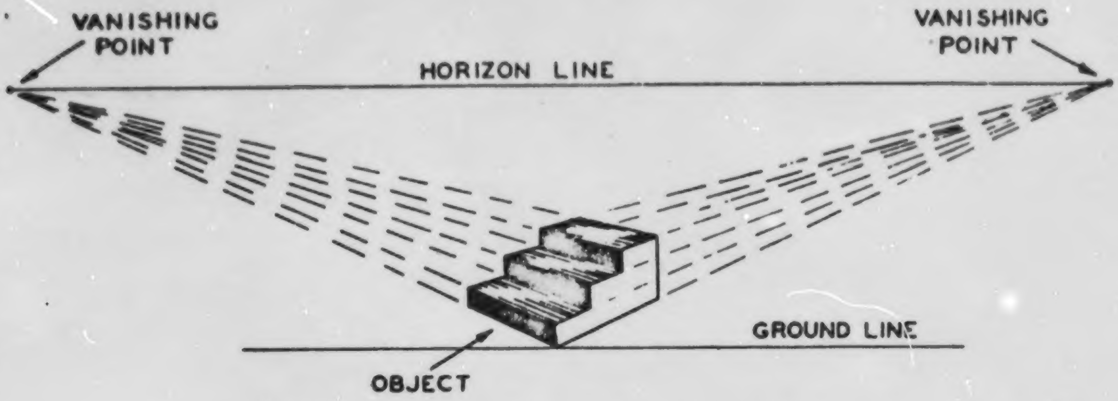


Figure 29. Perspective Drawing.

Oblique Drawing

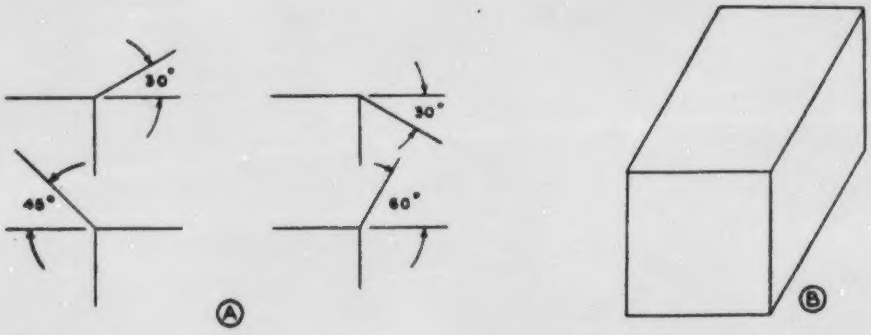


Figure 30. Oblique Drawing.

drawn more easily by an oblique drawing. Usually it is placed at 30°. Since one face of an oblique drawing is parallel to the picture plane, the face is not distorted. To a certain extent, the receding two surfaces will look distorted as in figure 30B.

INTERPRETING DRAWINGS

Types, Use, and Interpretation of Lines

The line is the basis for interpretation of drawings. A thorough knowledge of lines is essential to a welder. Figure 31 shows how various types of lines are drawn. Some of the most common lines and their use are shown in figure 31.

Dimensioning

Three types of dimensions are shown in figure 32; detail, position, and overall. A detail dimension shows one length or dimension necessary to express the size of an object. A position dimension locates the centers of circles or radii necessary to fabricate objects to exact dimensions. An overall dimension is a total dimension which is used to give the entire length, height, and width of an object. It is generally a summation of all included smaller dimensions and is placed on the outside of detail and position dimensions.

LETTERS AND FIGURES. All lettering and figures on AF drawings are placed horizontally in order to be read easily from the bottom of the drawing, as shown in figure 33. Unless otherwise specified, inch marks need not be used on drawings, since all dimensions are understood to be in inches. Where dimensions are in feet, or feet and inches, they will be marked as 12' or 12'8". Normally,

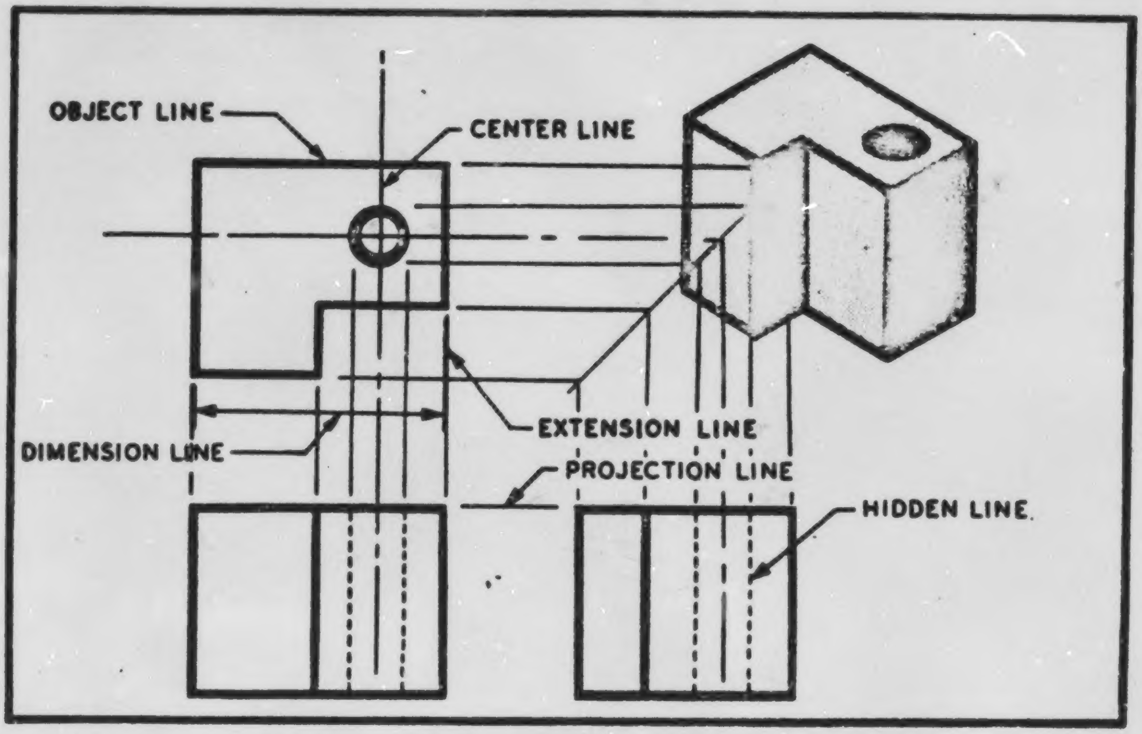

OBJECT LINE
CENTER LINE
EXTENSION LINE
DIMENSION LINE
PROJECTION LINE
HIDDEN LINE

Figure 31. How Various Types of Lines are Drawn.

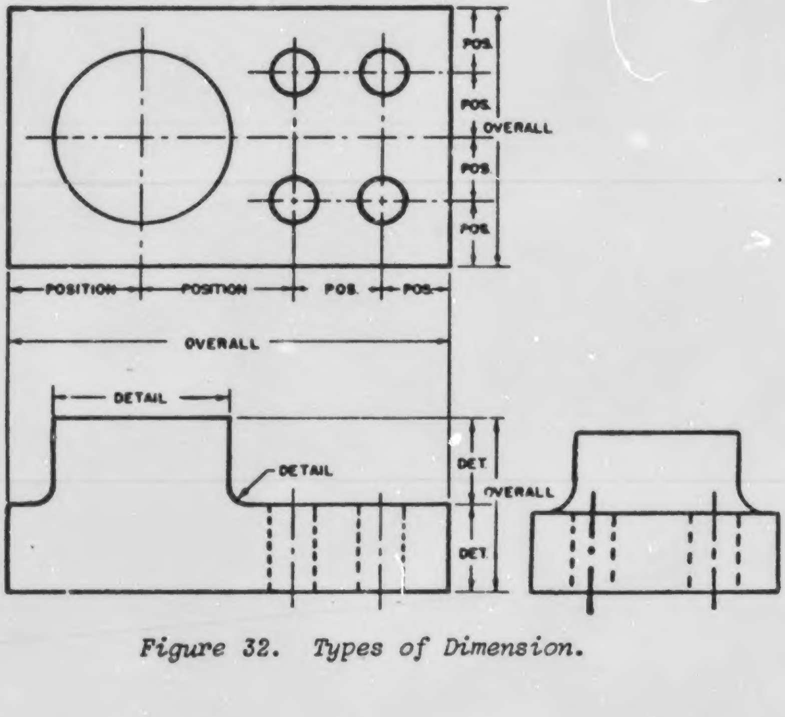

POS.
POS.
OVERALL
POS.
POS.
POSITION
POSITION
POS.
POS.
OVERALL
DETAIL
DETAIL
DET.
OVERALL
DET.

Figure 32. Types of Dimension.

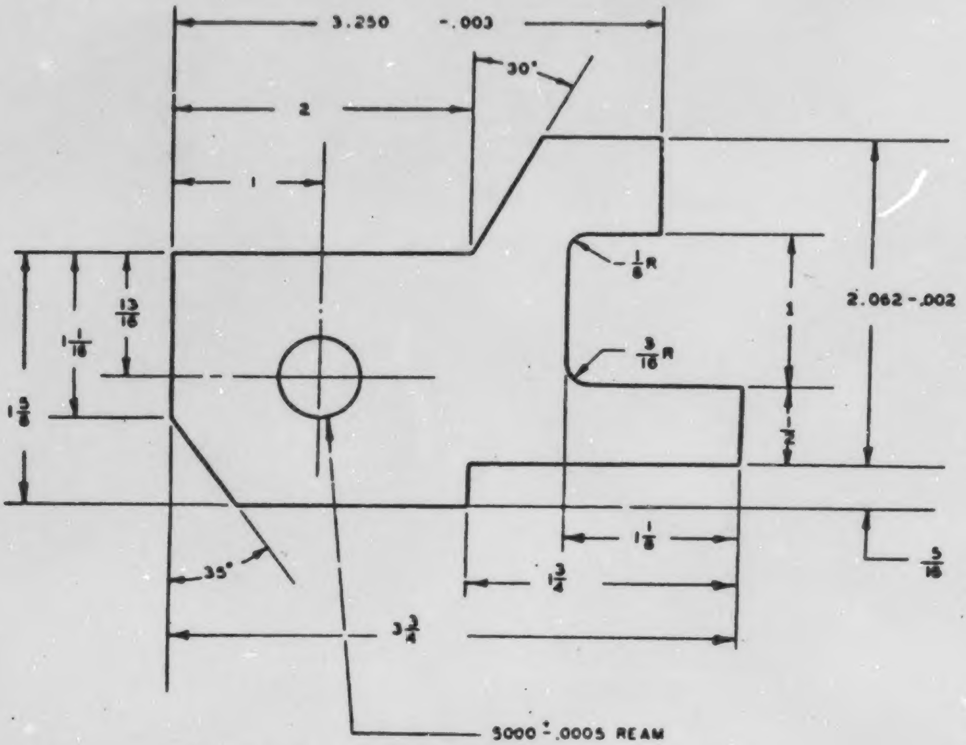
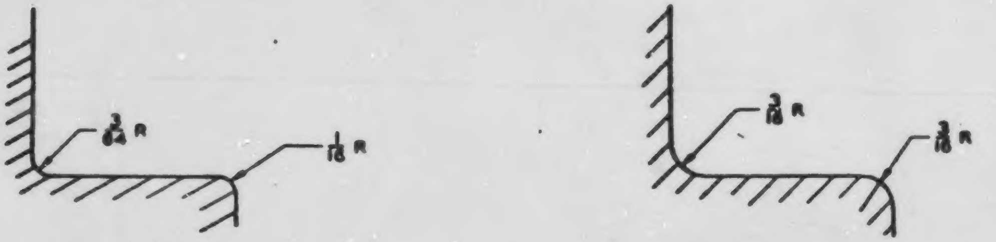
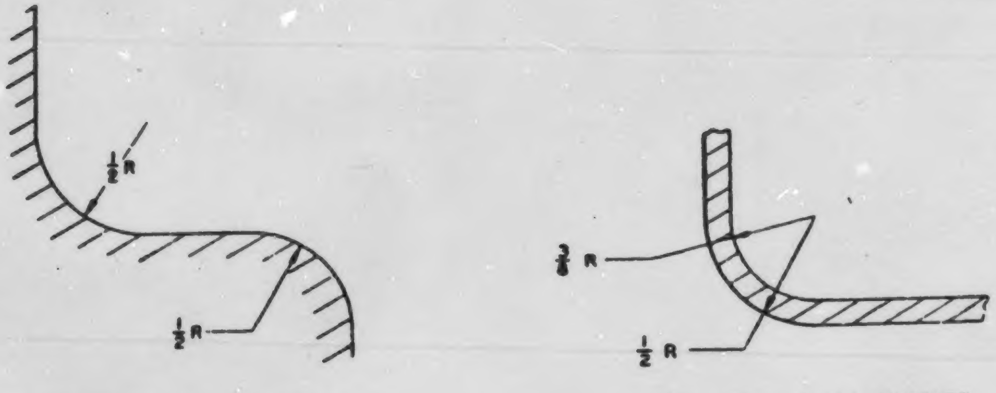

3.250 -.003
30°
2
1
13/16
1 1/16
1 5/8
- 1/8 R
3/16 R
1
2.062 -.002
1/2
1 1/8
1 3/4
5/16
35°
3 3/4
5000 ± .0005 REAM

Figure 33. Position of Letters and Figures.


3/64 R
1/16 R
3/16 R
3/16 R

FOR RADII UP TO 3/16

FOR RADII FROM 3/16 TO 1/2


1/2 R
1/2 R
3/8 R
1/2 R

FOR RADII 1/2 AND LARGER

FOR RADII CLOSE TOGETHER

Figure 34. Dimensioning Arcs and Radii.

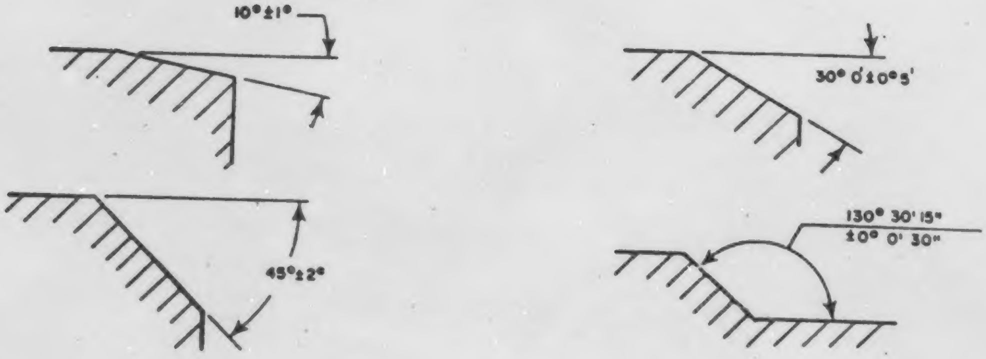

10° ±1°
30° 0' ±0° 5'
45° ±2°
130° 30' 15"
±0° 0' 30"

Figure 35. Dimensioning Angles and Chamfers.

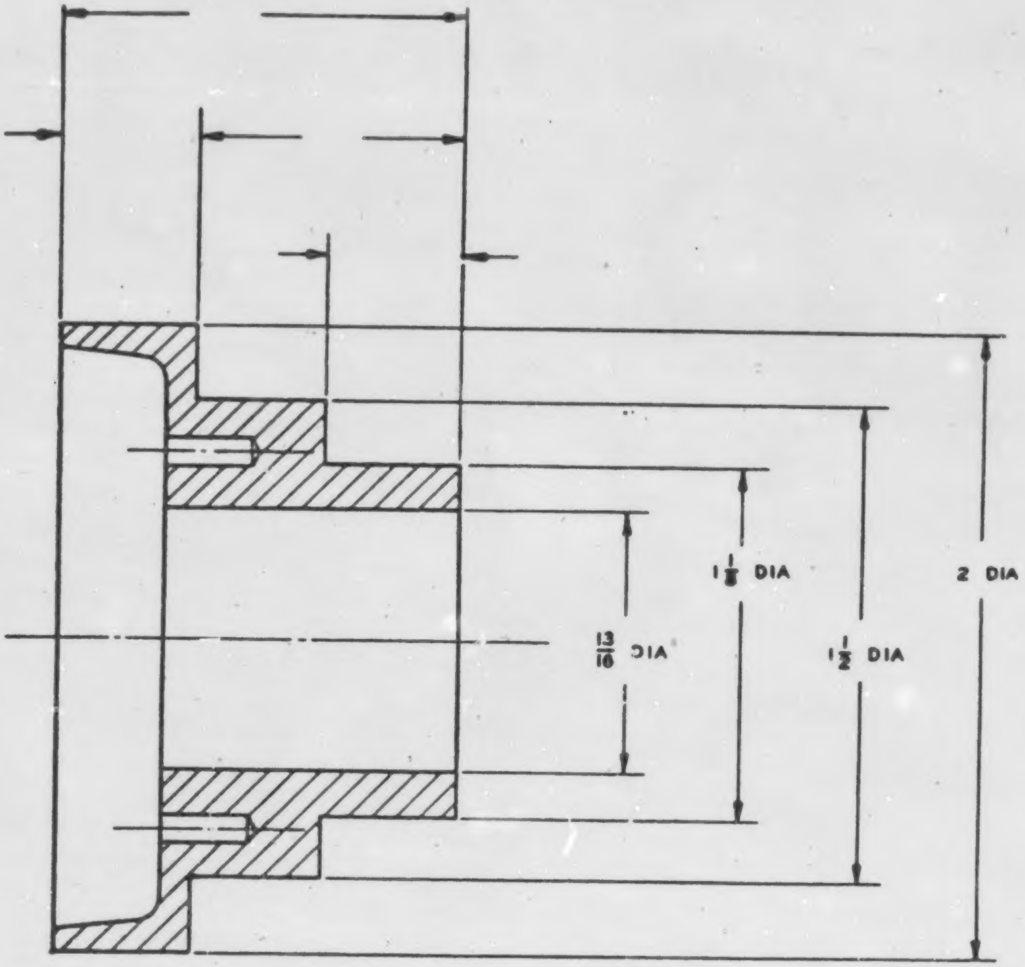

1 1/8 DIA
13/16 DIA
1 1/2 DIA
2 DIA

Figure 36. Dimensioning Circles.

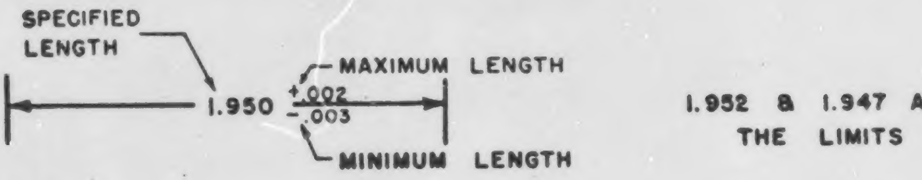


Figure 37. Limits.

in a machine drawing the symbol for feet is not used.

RADII. Methods of indicating radii of arcs and curves are shown in figure 34. Radius dimensions are shown as followed by the letter "R" and the dimension line has only one arrowhead.

ANGLES. Some examples of how angles are dimensioned are shown in figure 35. Depending upon the spacing between the extension lines, dimension lines and dipensions may be placed inside or outside the angles.

CIRCLES. Figure 36 is an example of how circles may be dimensioned. A dimension indicating the diameter of a circle is generally followed by the abbreviation "DIA."

HOLES. Holes which are to be drilled or reamed should have the diameter given, preferably on a leader line, followed by the word indicating the operation.

LIMITS AND/OR TOLERANCE. These are the extreme dimensions accepted. For example, a piece is to be made 1.950 long with a maximum dimension .002 inch larger and a minimum dimension .003 inch less than 1.950 inches. The extreme dimensions would be $1.950 {}^{+.002}_{.003}$ inches. 1.952 inches and 1.947 inches are the limits, as illustrated in figure 37. Tolerance is the amount of variation permitted in the size or location. In the above example, the tolerance or total amount of variation permitted is .002 + .003 = .005 inch.

Interpreting Sectional Views

A sectional view is obtained by imagining the object cut away as if by sawing (figure 38). The path of the saw is considered to be the cutting plane; i.e., the plane upon which the cut is made. If one portion of the object is then removed and a drawing made of the remaining portion, the lines formerly invisible are exposed to view. Since sectioning an object is an imaginary operation, the other necessary views are not changed. The only addition is a cutting plane line which traces the path of the cutting plane. A pictorial view of the object with the path of the cut traced by a diagonal line is shown in figure 38. An orthographic projection with the side view sectioned is also shown in figure 38. The position of the cutting plane is located on the projected view by a cutting plane line, as shown in figure 39. The view to be exposed after passing the cutting plane through the object is indicated by the direction of the arrows on the cutting plane line, as in figure 39. The cutting plane line may be omitted if the cutting plane line coincides with the centerline representing the symmetrical axis of the object.

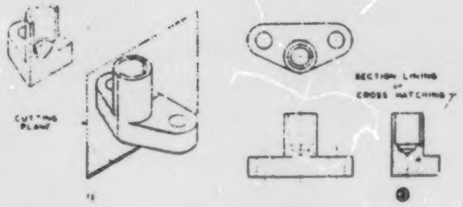


Figure 38. Sectional Views.

FULL SECTIONAL VIEW. A full sectional view is obtained by passing a cutting plane across the entire object (figures 38 and 40). In this operation, one-half of the object is considered removed; the other half, with the interior exposed to view, is drawn or projected

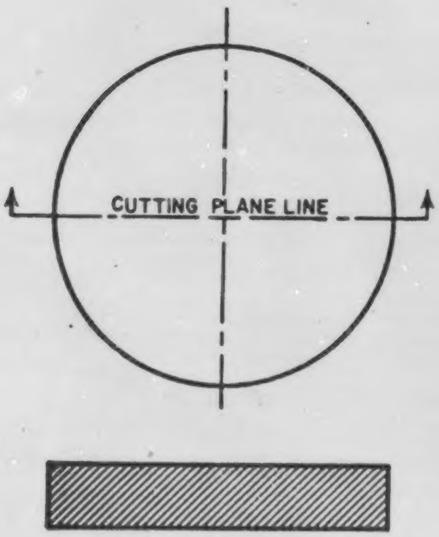


Figure 39. Cutting Plane Line.

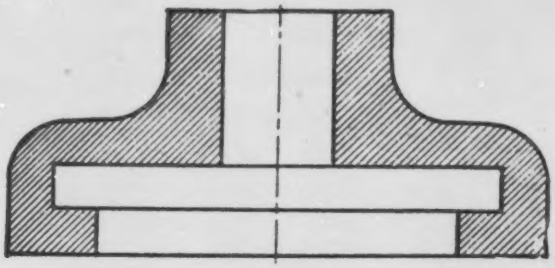


Figure 40. Full Section.

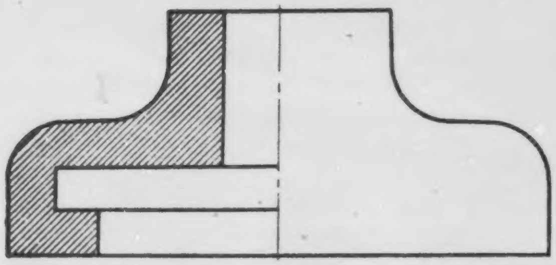


Figure 41. Half-Section.

in the manner of any other orthographic view.

HALF-SECTIONAL VIEW. A half-sectional view may be drawn for a symmetrical object (figure 41). This type of section is obtained by passing two cutting planes at a right angle to each other along the centerline or symmetrical axis. Thus, one-quarter of the object is considered removed and the interior exposed to view. To more clearly describe the object, invisible outlines are generally omitted from the sectioned and unsectioned portion. The half-section provides a view which shows the internal and external features of an object.

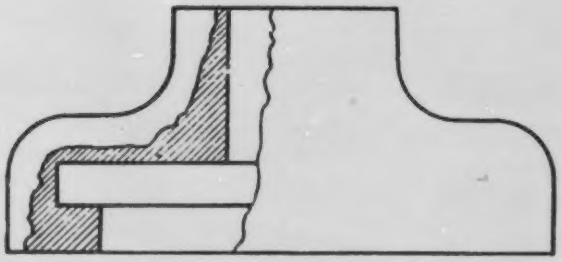


Figure 42. Broken-Out Section.

BROKEN-OUT OR PARTIAL SECTION. A broken-out or partial section is employed when it is desired to show only a portion of the object in sectional view (figure 42). Frequently, a broken-out section will eliminate the necessity of showing a full or half-sectional view. The broken-out section is bounded at the break by a short breakline.

Uniformly spaced 45°, fine, parallel lines, termed crosshatching or section-lining, are used to distinguish the surface of the material theoretically cut and exposed by the cutting plane. The spacing of crosshatching varies from 1/32 to 1/8 inch, depending on the size of the drawing and the part. Detail drawings are crosshatched with the symbol for cast iron regardless of the material used.

Methods of Showing Detail Not In Sectional Views

INVISIBLE OBJECT LINES. Invisible object lines and details beyond the cutting plane are not shown on sectional views unless required for description of the object.

ELIMINATION OF CROSSHATCHING. When a cutting plane passes through a rib, web, or similar parallel element, the crosshatching is omitted from those parts, as shown in figure 43. The plane

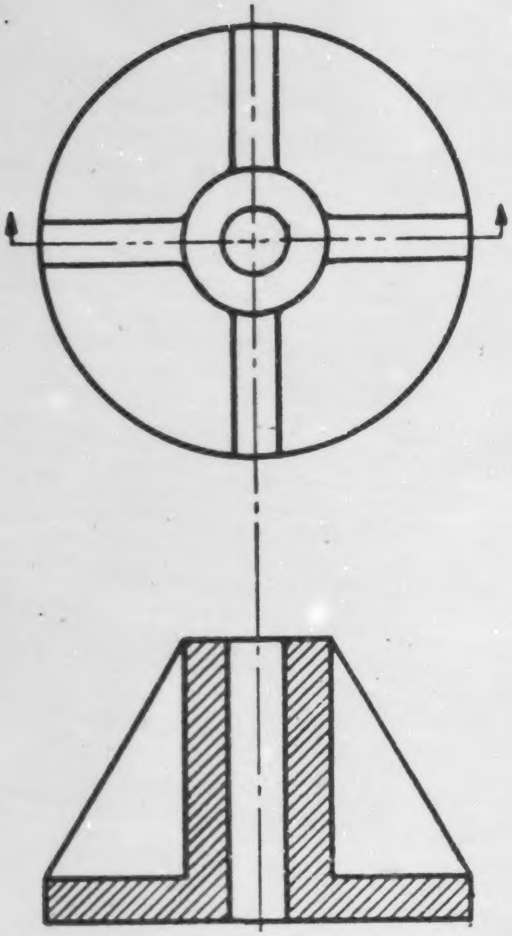


Figure 43. Ribs in Section.

is thought of as being just in front of the rib or web.

OPPOSITE DIRECTION CROSSHATCHING. When adjacent parts are shown in section, the crosshatching is shown in opposite directions. Where a third part is adjacent to two other parts, the angle of its crosshatching is made 30° or 60°.

Welding Symbols

Welding symbols place complete and concise welding information on drawings for the guidance of welders and other construction and maintenance personnel. The reference line of the welding symbol, shown in figure 44, is used to designate the welding process to be used, its location, dimensions, extent, contour, and other supplementary information. When necessary, a tail is attached to the reference line and utilized to provide specific notations (figure 44). However, the tail is omitted when such notations are not required.

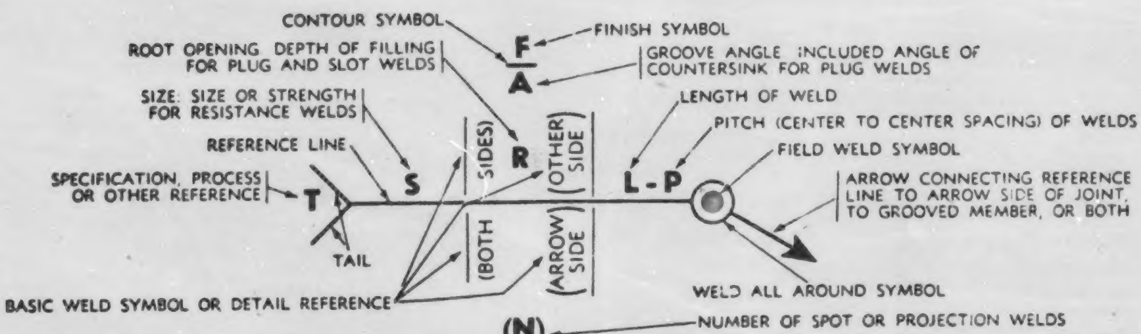
ELEMENTS OF A WELDING SYMBOL. The Army and Navy Standard for Welding Symbols (JAN-STD-19) makes a distinction between the terms "weld symbol" and "welding symbol." The weld symbol is the ideograph (A and B, figure 45) used to indicate the desired type of weld. The assembled welding symbol consists of the following eight elements or any that are necessary: reference line, arrow, basic weld symbol, dimensions and other data, supplementary symbols, tail, specification, process, or other reference. The location of the welding symbol elements with respect to each other is shown in figure 44.

BASIC WELD SYMBOLS. These weld symbols are used to indicate the welding processes used in metal joining operations to indicate whether the weld is localized or "all around," to indicate shop or field welds, and to indicate the contour of the welds. These basic weld symbols are summarized and illustrated in figure 45.

Arc and Gas Weld Symbols. These symbols signify bead, fillet, plug, or slot, square, V, bevel, U, and J welds, as shown in figure 45A.

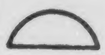
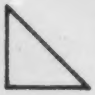
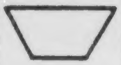
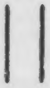
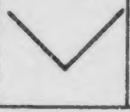
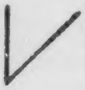
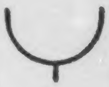
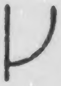
Resistance Weld Symbols. These symbols signify spot, projection, seam, flash, and upset welds, as shown in B, figure 45.

Brazing, Forge, Thermit, Induction, and Flow Weldments. No specific weld symbols have been assigned for these processes; therefore, the tail of the welding symbol is used, as in figure 44, to designate which of these welding processes is used, together with specifications, procedures, or other supplementary information required in making the weld. The codes for these notations in the welding symbol are usually established by their uses and

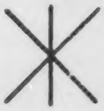
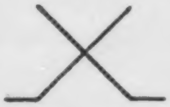
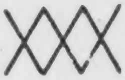
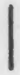

CONTOUR SYMBOL
F
FINISH SYMBOL
ROOT OPENING. DEPTH OF FILLING FOR PLUG AND SLOT WELDS
A
GROOVE ANGLE. INCLUDED ANGLE OF COUNTERSINK FOR PLUG WELDS
SIZE. SIZE OR STRENGTH FOR RESISTANCE WELDS
LENGTH OF WELD
PITCH (CENTER TO CENTER SPACING) OF WELDS
REFERENCE LINE
R
(OTHER SIDE)
(BOTH SIDES)
FIELD WELD SYMBOL
SPECIFICATION, PROCESS OR OTHER REFERENCE
T
S
L - P
ARROW CONNECTING REFERENCE LINE TO ARROW SIDE OF JOINT, TO GROOVED MEMBER, OR BOTH
TAIL
(ARROW SIDE)
BASIC WELD SYMBOL OR DETAIL REFERENCE
WELD ALL AROUND SYMBOL
(N)
NUMBER OF SPOT OR PROJECTION WELDS

RA PD 235985

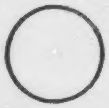
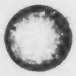
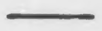
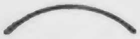
Figure 44. Standard Locations of Elements on a Welding Symbol.

TYPE OF WELD							
BEAD	FILLET	PLUG OR SLOT	GROOVE				
			SQUARE	V	BEVEL	U	J
							

A — BASIC ARC AND GAS WELD SYMBOLS

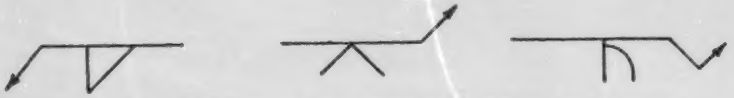
TYPE OF WELD			
SPOT	PROJECTION	SEAM	FLASH OR UPSET
			

B — BASIC RESISTANCE WELD SYMBOLS

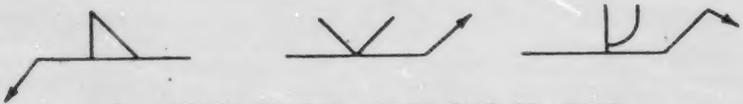
WELD ALL AROUND	FIELD WELD	CONTOUR	
		FLUSH	CONVEX
			

C — SUPPLEMENTARY SYMBOLS

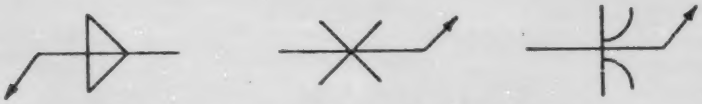
Figure 45. Basic Weld Symbols.



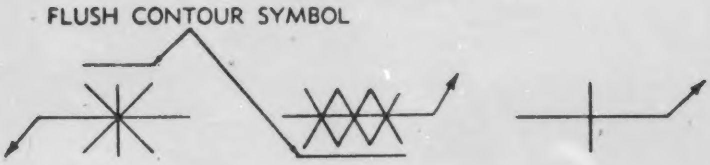
A— WELDS ON THE ARROW SIDE OF JOINT



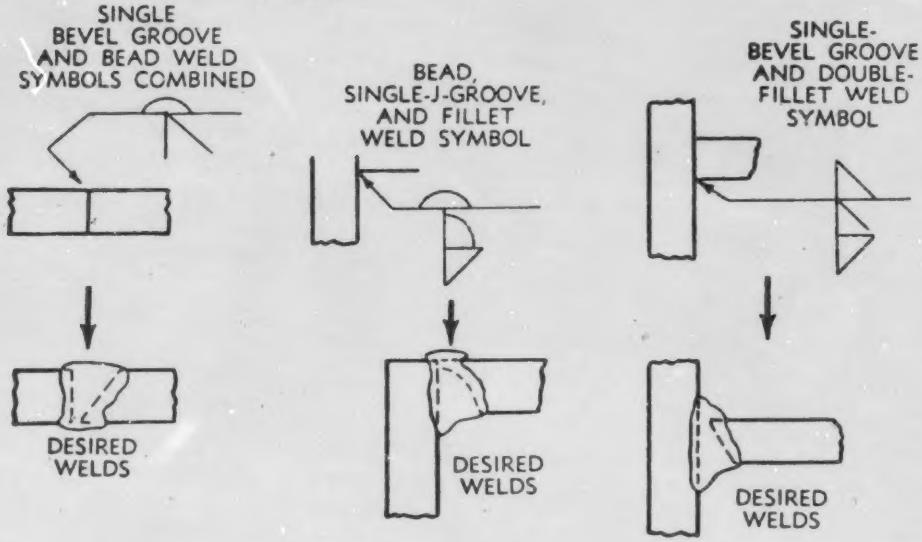
B— WELDS ON THE OTHER SIDE OF JOINT



C— WELDS ON BOTH SIDES OF JOINT


FLUSH CONTOUR SYMBOL

D— SPOT, SEAM, AND FLASH OR UPSET WELD SYMBOLS


SINGLE BEVEL GROOVE AND BEAD WELD SYMBOLS COMBINED
BEAD, SINGLE-J-GROOVE, AND FILLET WELD SYMBOL
SINGLE-BEVEL GROOVE AND DOUBLE-FILLET WELD SYMBOL
DESIRED WELDS
DESIRED WELDS
DESIRED WELDS

E— COMBINATIONS OF WELD SYMBOLS

Figure 46. Welding Symbols Indicating Type and Location of Welds.

are coupled with the table required for their translation.

Supplementary Symbols. These symbols designate requirements common in many welding processes and include symbols for weld-all-around, field weld, flush, and convex contour welds. These are shown in figure 45C.

Location of Weld Symbol On Welding Symbol Reference Line

ARROW SIDE OF JOINT. Welds on the arrow side of the joint are indicated by the weld symbol on the underside of the reference line, as in figure 46.

OTHER SIDE OF JOINT. Welds on the other side of the joint are indicated by the weld symbol on the upperside of the reference line, as in figure 46B.

BOTH SIDES OF JOINT. Welds on both sides of the joint are indicated by the weld symbols on both sides of the reference line as in figure 46C.

SPOT, SEAM, AND FLASH OR UPSET WELDS. The symbols for these welds have no arrow side or other side significance in themselves; although, supplementary symbols used in conjunction with these symbols may have such significance. For example, the flush-contour symbol is used in conjunction with the spot and seam symbols (figure 46D) to show that the exposed surface of one member of the joint is to be flush. Spot, seam, and flash or upset weld symbols are centered on the reference line, as shown in figure 46D.

COMBINATION OF WELD SYMBOL. When more than one type of weld is used on a joint, the symbol for each weld is shown (figure 46E).

QUESTIONS

> Note: Do not write in this study guide. Answer all questions on a separate sheet of paper.

1. What is the purpose of an orthographic drawing?

2. What measurements are indicated in the top view of an orthographic drawing?

3. What measurements are indicated in the side view of an orthographic drawing?

4. What is the difference between orthographic and isometric drawings?

5. What measurements are indicated in the front view of an orthographic drawing?

6. What is an isometric line?

7. What is the purpose of center lines?

8. What is the purpose of hidden object lines?

9. What is a working drawing?

10. What is the purpose of dimensions on drawings?

11. How is the size of a circle or hole indicated on a drawing?

12. What is meant by sectional views?

13. How is a cutting plane line indicated on a drawing?

14. What are the three types of sectional views?

15. How is the exposed surface shown on a sectional view?

INTERPRETATION OF AIR FORCE BLUEPRINTS

General Features of Blueprints

Literally thousands of blueprints are needed to build one aircraft. A manufacturer who wants to build an aircraft according to AF specifications first consults his engineers. They work out all the requirements, limitations, shapes, and dimensions of the various component parts. This information is drawn up in the form of rough layouts, freehand sketches, and notes. This is then given to the draftsman who will assemble the information into engineering (mechanical) drawings. These drawings require considerable skill and attention to detail and in themselves would be too costly and

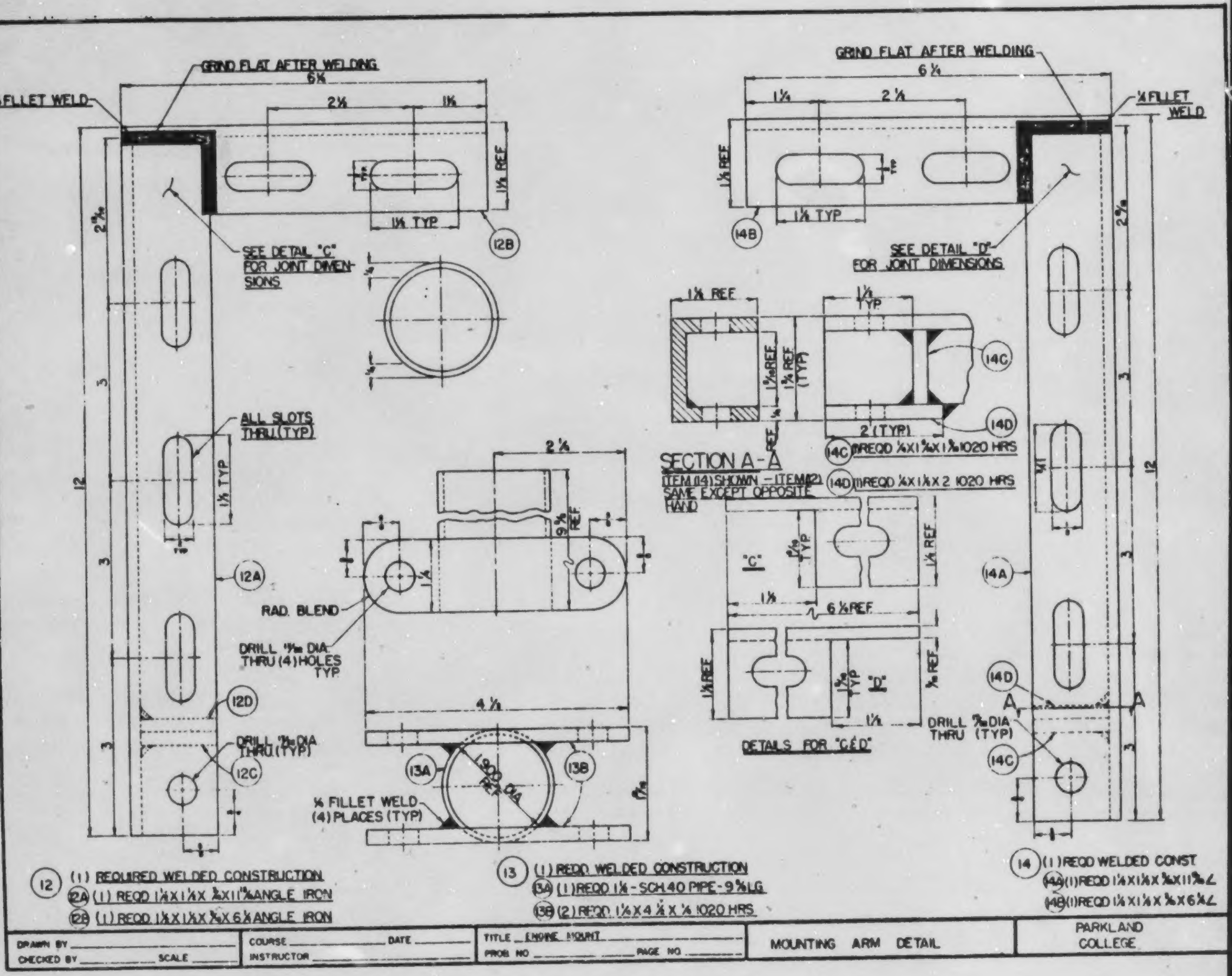

GRIND FLAT AFTER WELDING
6¼
¼ FILLET WELD
2¼
1¼
1¼ REF
1¼ TYP
12B
SEE DETAIL "C" FOR JOINT DIMENSIONS
ALL SLOTS THRU (TYP)
1¼ TYP
12
3
3
3
12A
12D
DRILL ¹³⁄₃₂ DIA THRU (TYP)
12C
2¼
9⅞ REF
RAD. BLEND
DRILL ¹³⁄₃₂ DIA THRU (4) HOLES TYP
4½
13A
1.900 DIA REF
13B
¼ FILLET WELD (4) PLACES (TYP)
14B
SEE DETAIL "D" FOR JOINT DIMENSIONS
1¼ REF
1¼ TYP
14C
14D
2 (TYP)
SECTION A-A
ITEM (14) SHOWN - ITEM (12) SAME EXCEPT OPPOSITE HAND
14C (1) REQD ¼X1⅝X1⅝ 1020 HRS
14D (1) REQD ¼X1¼X2 1020 HRS
"C"
"D"
6¼ REF
DETAILS FOR "C & D"
14A
A
A
DRILL ¹³⁄₃₂ DIA THRU (TYP)
12 (1) REQUIRED WELDED CONSTRUCTION
12A (1) REQD 1¼X1¼X ⅛X11⅞ ANGLE IRON
12B (1) REQD 1¼X1¼X⅛X6¼ ANGLE IRON
13 (1) REQD WELDED CONSTRUCTION
13A (1) REQD 1½ - SCH 40 PIPE - 9⅞ LG
13B (2) REQD 1¼X4½X¼ 1020 HRS
14 (1) REQD WELDED CONST
14A (1) REQD 1¼X1¼X⅛X11⅞∠
14B (1) REQD 1¼X1¼X⅛X6¼∠
DRAWN BY
CHECKED BY
SCALE
COURSE
DATE
INSTRUCTOR
TITLE ENGINE MOUNT
PROB NO
PAGE NO
MOUNTING ARM DETAIL
PARKLAND COLLEGE

Figure 47. Detail Drawings.

short-lived to be practical. A convenient and economical means of accurately reproducing such drawings is blueprinting.

Blueprints are actual copies of engineering drawings which bridge the gap between design and construction. They give complete information to the fabricator or repairman by telling him what to do and where to go, as shown in figure 47. Aircraft maintenance personnel use several kinds of drawings to repair and maintain aircraft. Technical order drawings, such as major assembly breakdowns, subassembly breakdowns, and structural diagrams are constantly used to simplify locating thousands of small parts used in the overall construction of an aircraft.

Blueprints are not always blue. They are sometimes white with black, blue, purple, or maroon lines. The first method of reproducing mechanical drawings proved to be the cheapest and the most common method employed in blueprinting. A mechanical drawing is placed of a chemically-treated white sheet of paper. When exposed to a strong light, the chemical on the paper turns blue. Since the lines on the mechanical drawing are opaque, they hold back the light and the result is that white lines appear on a blue background. Other methods of reproducing mechanical drawings are similar.

Other Information Found On Blueprints

TITLE BLOCK. The title block used on AF drawings is of a standard form. The title blocks used by the various manufacturers are not identical in form; however, the information contained in blocks is similar. The title block is located in the lower right section of the drawing or blueprint. The size of the block usually remains the same regardless of the size of the drawing. The title block contains information that is not directly related to the construction of the article but is necessary for reference purposes. The block is divided into sections and contains the following:

Finish Nomenclature. This section provides an explanation of the finish symbols. On AF drawing, the grade of finish is indicated by placing the index number in the small circle forming the tail of the letter "F." These are placed on the lines showing the finished surfaces. When many surfaces are to have the same finish, a standard "F" may be placed on the surfaces with the finish symbol located with notes. To indicate the kind of finish desired on remaining surfaces, an index number is placed in the blank finish mark at the bottom of this section. Although the finish symbols found on Air Force and various factory drawings are not identical, the method of indicating finishes is similar and generally self-explanatory.

Tolerances. The tolerance is the amount of variation permitted in size and location. Indicated in this section are the general tolerances applying to all dimensions not having individual tolerances included with basic dimension. Tolerances are given in fractions, decimals, and angles.

Material. The materials to be used in making the article are noted along with optional materials. Usually, reference is made to notes because of the limited space in this block.

Treatment. The heat treating process (annealing, case-hardening, etc.) to be used, is indicated in this section.

Finish. Reference is made to the type of finish to be applied to the article.

Draftsman. The name of the person making the drawing is listed along with the date of completion.

Checker, Engineer, Examiner. The names of persons responsible for the accuracy and correctness of the drawing are noted in corresponding spaces.

Production Approved. The date the drawing was approved for production purposes is shown along with the name of the person making the approval.

Name. The nomenclature of the article is indicated with the most suitable noun first, followed by a dash

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and necessary descriptive words; such as, "bolt - clamping ring," "propeller hub," etc.

Scale. Detail drawings are usually made to actual size. Large parts and assemblies may require drawing on a reduced scale if information can be clearly shown. The preferred scales are full (actual) size, 2, 4, 1/2, and 1/4 (figure 47).

> Note: When the drawing is two times as large as the object, the scale is "2"; if the object is two times the size of the drawing, the scale is "1/2."

Quantity Required. The number of parts required to complete the next assembly and the final assembly will be entered in the appropriate spaces. The next assembly number will be listed along with the type of equipment. The type is filled in only when the drawing applies to an aircraft, engine, or electronic equipment.

Drawing Number. This number is assigned to the drawings and later becomes the part number of the article. Composition of the numbers is described in an earlier paragraph. The number is located in the lower right corner of the drawing form. On Air Force drawings, a duplicate number will appear in the upper right corner for size A drawing form, in the upper center for sizes B, G, T, and in the center right for sizes C, D, E, F, H, J, and K. Manufacturers employ a similar method of locating numbers.

> Note: A diagonal line appearing in a section indicates no action will be taken.

Change Block. The change block is located in the upper right corner of the drawing form. All of the changes for a particular drawing are recorded in this section along with the date of change and the code number or letter for the change.

Patent. The patent clause is a statement located in the upper left corner of AF engineering drawings and deals with the patent rights of government drawings. This clause also relieves the government of any responsibility or obligations when the drawing is used for purposes other than government procurement.

General and Local Notes. Shop notes are used to give information and instructions that cannot be shown conveniently by other means. General notes are of a general nature and apply to drawings as a whole. They are located to the left and just above the title block. They are placed one above the other and each note numbered beginning at the bottom. Notes of this type indicate finish, hardness, material, etc. Local notes apply to specific parts of drawings and are located near the area affected. Local notes usually indicate operations but may also identify parts, give dimensions, and provide other specific information.

QUESTIONS

> Note: Answer the questions at the end of this chapter on a separate sheet of paper. DO NOT WRITE IN THIS STUDY GUIDE.

1. What is the purpose of a blueprint?

2. What information is found in the title block?

3. What does the scale "1/2" signify?

4. What is the purpose of the change block?

5. Where are general notes located?

6. What type of lines signify a center line of a hole through the center of a steel plate?

7. What type of information does the local notes give the reader?

8. What type of line signifies the outline of an object?

9. What is the purpose of a drawing or a blueprint?

10. What grade of pencil is preferred for mechanical drawings?

11. Why is it necessary for a metals processing specialist to know how to draw?

12. How many degrees are in a circle?

13. What does bisect mean?

14. What are parallel lines?

15. What is a right angle?

REFERENCES

1. Welch, Herbert O., Basic Mechanical Drawing, 1959.

2. Coover, Shriver L., First Course in Drawing and Basic Blueprint Reading, 1960.

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JOINTS OF HEAT AND CORROSION RESISTANT FERROUS ALLOYS

OBJECTIVES

After completing this study guide and classroom instruction, you will apply the welding procedures and techniques necessary to weld lap, butt, and tee joints of heat and corrosion resistant ferrous alloys.

INTRODUCTION

Heat and corrosion resistant ferrous alloys, usually referred to as stainless steels, are weldable by all welding methods. Welds made by oxacetylene, metallic arc, or inert gas shielded arc welding will develop a strength equal to that of the base metal in the annealed condition. These steels have a melting point of 2400° to 2600°F. The coefficient of expansion is about 50 percent greater than that of carbon steel and the thermal heat conductivity is from one-third to one-half less. In welding these steels, extra care should be taken to provide for expansion and contraction.

INFORMATION

MANAGEMENT OF DEFENSE ENERGY AND RESOURCES

Due to the conservation of energy resources, do not write in or mark on any training literature since it will be reused by other classes. Lights will be turned off any time the classroom is vacant for more than 20 minutes. All consumable materials will be used conservatively throughout Block II.

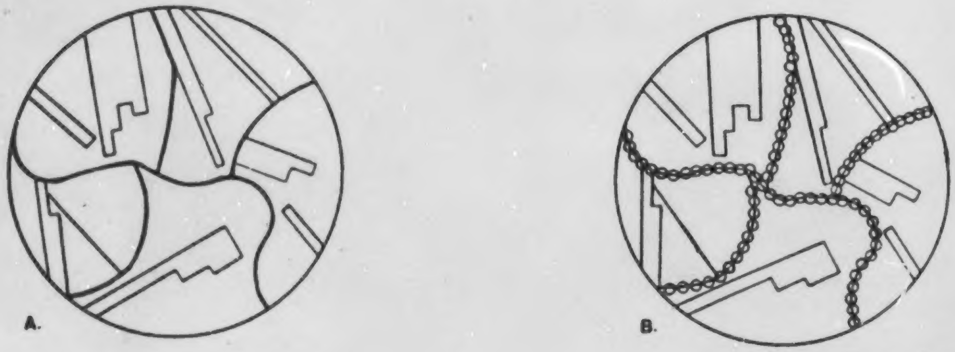
CARBIDE PRECIPITATION

Basically, two types of stainless steels are encountered in the shop for aircraft applications. They are types 321 and 347; both are stabilized by the addition of certain percentages of other alloying elements. In type 321 the stabilizing agent is titanium; in type 347 it is columbium. These elements help to prevent carbide precipitation during the cooling period from high temperatures. Carbide precipitation is the movement of the carbide from the inside of the material to the outside (figure 48). The carbides are burned by the oxygen in the air and fall off in the form of scale. The thickness of the metal is reduced each time it is heated to temperatures from 800°F to 1600°F and cooled slowly in the air. After welding, the metal should be heated to 1850°F and 2100°F. and cooled quickly. This places the carbides back in solution and the corrosion resistant properties are retained.

Control of Oxidation, Distortion, and Warpage

Oxidation, distortion, and warpage can be controlled by proper welding procedures. Oxidation occurs readily if the metal is heated with a flame of excess oxygen. A strictly neutral flame is most desirable but it is difficult to maintain and may change from the neutral to the oxidizing flame without being noticed. When using a slightly carburizing flame, the feather or brush-like second cone should not extend more than 1/16th inch beyond the tip of the inner cone. If the flame contains more acetylene than required, the weld will be brittle. Distortion and warpage are prevented by the use of jigs or fixtures. They should be designed to allow a maximum movement of the part. This will prevent cracking due to the metal contracting as it cools.

To prevent oxidation of the weld, corrosion resistant steels should be well protected from the air during welding. Oxidation is kept to the minimum by using flux in oxyacetylene welding. The flux is in the powder form and is mixed in clean, cold water to form a cream-like paste. The flux is applied to both sides of the joint and also to the rod. The flux



A. Structure Before Carbide Precipitation.
B. Structure With Chromium Carbides Deposited at Grain Boundaries.

Figure 48. Carbide Precipitation.

protects the metal that cannot be covered by the flame.

The end of the welding rod should be kept within the limits of the flame envelope and added to the weld by allowing it to melt and flow into the molten puddle. Stirring or puddling the hot metal with the rod is not necessary and should be avoided. The welding tip should be one size smaller than is used for a similar thickness of ordinary carbon steel and should not give a flame that forks or spreads.

Welding Lap Joints

The welding of a lap joint in stainless steel is usually not as difficult as welding a butt joint. Lap joints are frequently used in the repair of aircraft manifolds when the additional thickness of a lap joint is permitted. They also require less accurate fitup in the repair of holes or worn sections. The chance of oxidation is greatly reduced since the penetration for lap joints does not extend to the bottom of the joint. When the design of the part does not permit welding from both sides, the joint may be welded from one side only. For some applications, such as in the repair of weldable jet or conventional aircraft parts, patches forming a lap joint are applied to repair holes or worn sections. Freedom of pin holes, corrosion resistance, and the necessary strength to withstand expansion and contraction stresses are the main requirement for welds on these parts.

METAL PREPARATION. The removal of oxides, greases, or oil is necessary, as in welding other metals, to prevent their inclusion in the weld. The joint edges require no special preparation other than the removal of burrs.

SETUP AND TACK WELDING. The top edge of the lap joint must be closely fitted to the surface of the lower sheet. Spacing between the joint edges would cause the upper edge of the joint to overheat making welding more difficult. Tack welds must be rigid and spaced close together along the entire joint. Make sure there is a close fitup after tacking to prevent the edges from separating during welding. Tack welding aids in reducing warpage due to the high coefficient of expansion of stainless steel. Figure 49 illustrates a properly tack welded lap joint. For best results, tack welds should be spaced no more than 1 inch apart. They must be made rigid, yet small, to permit easy fusion within the weld.

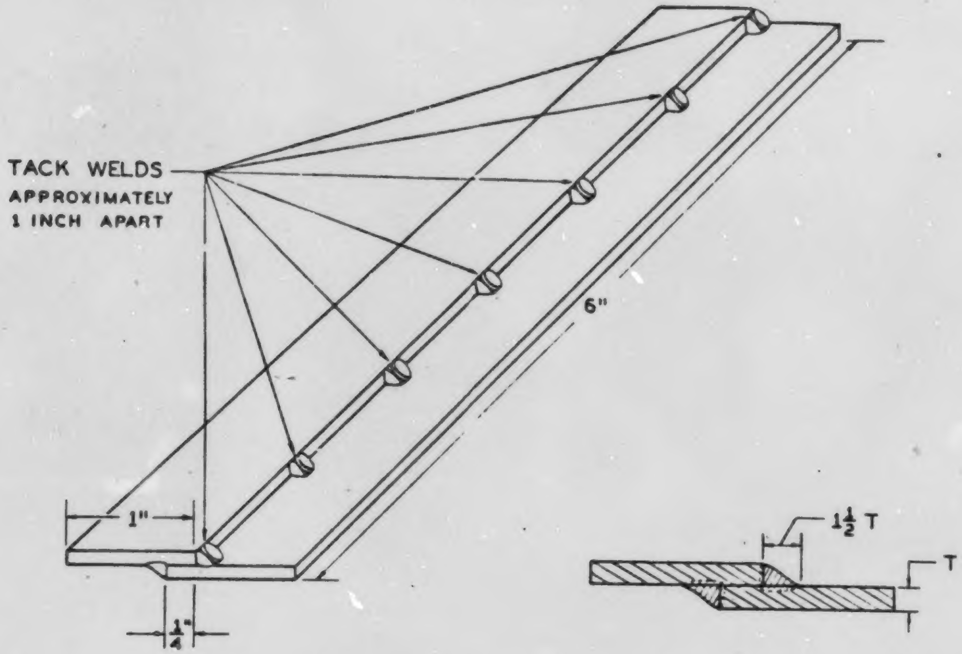


Figure 49. Lap Joint.

WELDING APPLICATION. It is not necessary to use flux to protect the molten metal penetrating the joint, but it is in butt joints. However, some oxidation will take place directly below the line of fusion. For this reason, a coating of flux may be placed directly beneath the line of weld on the underside of the sheet.

The joint should be preheated for several inches by directing the flame above and below the joint. This will raise the metal to welding temperature at the root of the joint. The flame is directed mainly on the bottom sheet and is pointed in the direction of travel. When the edges are raised to the molten state, the center of the molten pool should be in line with the unmelted edge of the joint. This permits the base metal to be melted into the molten pool; thus, requiring less filler rod and assuring adequate penetration into the root and upper edge of the sheet.

The filler rod is held at the forward edge of the molten pool and melted simultaneously with the base metal. The filler rod must be kept within the limits of the outer flame envelope. This provides a protective shield for the molten pool, the surrounding metal, and the melting end of the filler rod. The weld should be completed without interruption. If the weld must be stopped for any reason, the flame should be withdrawn slowly to prevent oxidation of the melting metal.

General Procedures

1. Clean the metal to be welded and flux the underside of the joint.

2. Set up the sheets without any space between them.

3. Adjust the flame to slightly carburizing with 1/16" feather.

4. Tack weld at one-inch intervals making the tacks as small as possible.

5. Start at one end and complete the weld. Direct the flame mostly on the bottom sheet.

6. Add filler rod near the top edge of the joint. Keep the rod slightly in advance of the pool and allow the molten metal to flow into the pool.

7. Turn the work over and weld the other side.

8. Check with instructor for appearance and penetration.

Precautions

1. Be sure the pieces fit tightly together after tacking.

2. Make sure to use the correct flame with a minimum of heat.

3. Be sure to protect the molten pool with the flame at all times.

WELDING BUTT JOINTS

Metal Preparation

Square edge butt joints may be used on metal thickness up to 1/8 inch. Welding metal of greater thickness requires beveling of the edges, as in carbon steels. All scale, oxides, and traces of grease or oil must be removed to prevent their inclusion in the weld. The closer the characteristics of the deposited metal approximate those of the metal being welded, the better the corrosion resistance of the welded joint.

Setup and Tack Welding

Proper spacing, size, and penetration of tack welds aid in maintaining alignment of the joint and reduce the possibility of excessive warpage. The spacing between the edges of the sheet should not exceed the metal thickness after tacking. Due to the high coefficient of expansion, tack welds must be made with complete penetration and spaced approximately one inch apart along the entire joint. Figure 50 shows the proper setup for welding a rigid butt joint. After flux has been applied to the bottom edges of the joint, care must be taken to place the edges of the joint on the same plane. The torch is directed approximately perpendicular to the joint to raise the metal to the molten state. The filler rod is then added to the melting edges to form the tack weld. To avoid oxidation resulting from removing the flame too quickly from the molten metal, the outer flame envelope should be directed over the tack weld and slowly withdrawn until it solidifies. Tack welds must be rigid with full penetration; yet, small enough to permit easy fusion of the metal in welding. The bottom edges of the joint should be refluxed after tack welding to replace the flux removed by the flame in the area of the tacks.

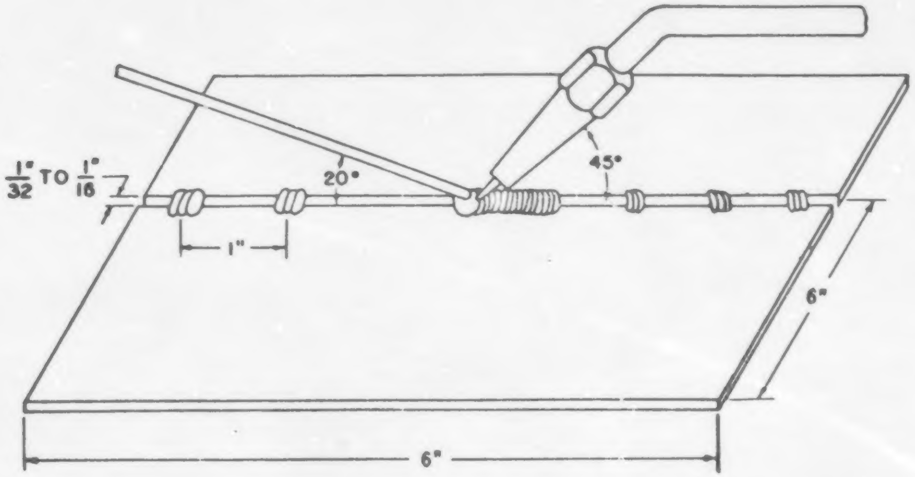


Figure 50. Welding Rigid Butt Joints (Forehand Technique).

Welding Application

Best results are produced in welding heat and corrosion resistant steel by completing the weld as rapidly as possible with a minimum of heat. Excessive and prolonged heating results in increased carbide precipitation, distortion, and buckling. The torch tip should be one or two sizes smaller than that used in welding carbon steels of equal thicknesses. The welding flame is adjusted to slightly carburizing. When properly adjusted, the "feather" visible on the end of the inner cone should not exceed 1/16 inch. The flame is directed at an angle of 45 degrees in the direction of travel. The filler rod is added to the molten pool at an angle of approximately 20 degrees with the surface of the sheet and is added to the forward edge of the pool. This technique permits the filler rod to fuse simultaneously with the base metal. The outer flame envelope serves as a protective shield over the molten pool, surrounding metal and the melting end of the filler rod. The weld should progress with a steady forward movement of the torch. Lateral movement of the torch causes the heat to spread, increasing the tendency toward buckling and distortion. Whenever possible, welds should be completed without interruption. If, for any reason, the weld is stopped along the joint, preheating to a dull red heat is necessary before restarting the weld.

Procedure

1. Clean the metal to be welded and flux the underside of the joint.

2. Set up on firebricks in the welding position.

3. Adjust the flame to slightly carburizing with about 1/16" feather.

4. Allow proper spacing and tack weld at one-inch intervals. Make the tacks as small as possible.

5. Hold the torch and rod at the angle shown in figure 50.

6. Start at center of the joint and weld toward the ends, always keeping the rod slightly ahead of the pool, allowing the metal to flow into the pool.

7. Do not stir or puddle the molten pool.

8. Feather off at the finish of each weld.

9. Check for weld faults by bending through the weld.

10. Check your work with the instructor after bending.

Caution:
1. Make the tack weld as small as possible.
2. Be sure to feather off each tack.
3. Make sure the proper spacing is allowed and the metal is aligned after tacking.
4. Reflux the underside of the sheet after tacking.

WELDING TEE JOINTS

Metal Preparation

The removal of oxides, greases, or oil is necessary, as in the welding of lap and butt joints. The joint edges require only cleaning and removal of burrs.

The plain tee joint may be used on metals up to 1/8 inch in thickness. Metals of greater thickness require beveling, as in welding carbon steel. The vertical sheet is spaced approximately 1/32 inch above the horizontal sheet. This spacing permits easier fusion into the root of the joint without excessive heating. Figure 51 illustrates the proper spacing of tack welds. They must be made rigid, yet small enough to permit easy fusion with the weld and spaced not more than 1 inch apart. Tack welds should be made alternately on both sides when the joint is to be welded on both sides of the vertical sheet. Tack welding in this manner aids in maintaining alignment of the vertical sheet.

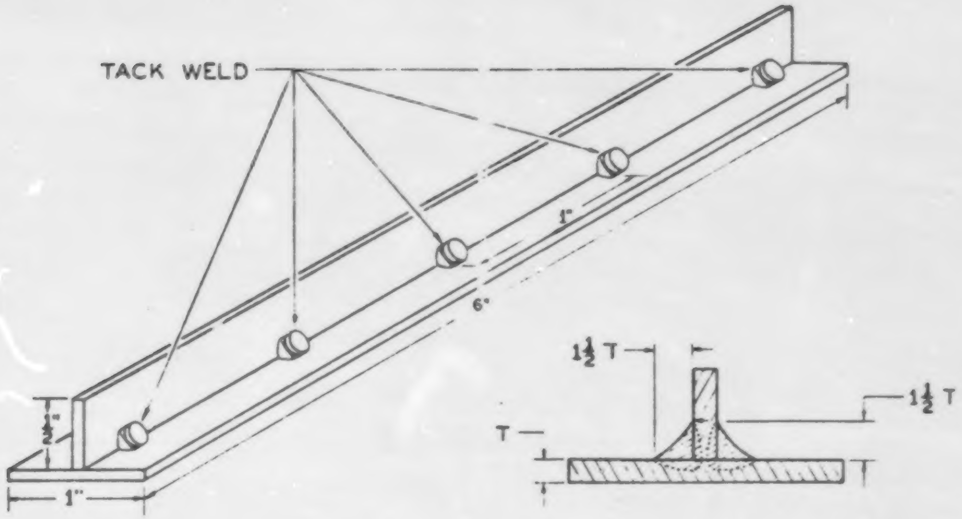


Figure 51. Tee Joint.

Welding Application

The correct volume of heat is of utmost importance in welding a tee joint. If excessive heat is used, the surface on the opposite side of the vertical sheet will oxidize and make welding extremely difficult. Oxidation can be minimized by applying flux to the backside of the joint. This side must be thoroughly cleaned before you begin the weld.

Preheating is done by directing the flame above and below the joint, raising the metal to the welding temperature at the root of the joint. Adequate preheating prevents cracks from forming along the line of weld. When welding, the torch is pointed in the direction of travel with the flame directed mainly upon the base of the tee joint. When the base metal is raised to the welding temperature, the molten pool should extend equally upon the vertical and horizontal sheets. A requirement for tee joints is to produce a weld with the upper and lower legs equal in length.

The filler rod is held at the forward edge of the pool and added at its upper edge. This allows the molten metal to flow into the pool and helps prevent possible undercutting of the upper sheet and overlap on the lower sheet. The flame must constantly shield the melting metal to prevent oxidation. Whenever a weld is stopped or is at the end of a joint, feathering off will prevent oxidation.

Procedure

1. Clean the metal to be welded and flux the underside and backside of the joint.

2. Adjust the flame to slightly carburizing with 1/16" feather.

3. Set up the work, as shown in figure 51, and tack weld at 1" intervals.

4. Weld by the forehand method, directing most of the flame on the bottom sheet.

5. Add the filler rod to the upper part of the joint, keeping the rod within the limits of the flame and allowing molten metal to flow into the pool.

6. Feather off at the end of the weld.

7. Clean the backside of the joint thoroughly and then repeat the procedure.

QUESTIONS

Note: DO NOT WRITE IN THIS STUDY GUIDE. Due to the conservation of paper, answer all questions on a separate sheet of paper.

1. What is carbide precipitation?

2. What is the carbide precipitation range?

3. What is the proper oxyacetylene flame used for welding heat and corrosion resistant ferrous alloys? Why is this flame used?

4. What type of stainless steel is commonly used by the Air Force?

5. Why is the "feathering-off" effect employed whenever a weld is stopped?

6. Why is the correct volume of heat of the utmost importance in welding a tee joint of stainless steel?

7. Why should tack welds be made alternately on both sides of a tee joint?

8. Why is a coating of flux placed directly beneath the line of weld on the underside of the sheet when welding stainless steel?

REFERENCES

1. TO 34W4-1-5, Welding Theory and Application.

2. TO 1-1A-9, Aerospace Metals - General Data and Usage Factors.

3. TO 42D5-1-1, Welding, Machining, and Forming Corrosion-Resistant Steels and Nickel-Chrome Iron Alloys.

MODIFICATIONS

Pages 35-51 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

CUTTING CARBON STEEL

OBJECTIVES

After completing this study guide and classroom instruction, you will identify the factors pertaining to oxyacetylene cutting and cut carbon steel with the oxyacetylene torch.

INTRODUCTION

Oxyacetylene cutting is a fast and economical method of cutting steel. The cutting torch allows the welder to make accurate fitups and prepare joint edges on the job without having to rely on time consuming mechanical methods.

INFORMATION

MANAGEMENT OF DEFENSE ENERGY RESOURCES

Due to the conservation of energy resources, do not write in or mark on any training literature since it will be used by other classes. Lights will be turned off any time the classroom will be vacant for more than 20 minutes. All consumable materials will be used conservatively throughout Block II.

CUTTING CARBON STEEL

Cutting carbon steel by the oxyacetylene process is basically the rapid oxidation of the metal in a localized area. It is a chemical process based on the affinity of oxygen to ferrous metal. When metal is heated to, or above, the melting temperature and a free jet of high pressure oxygen is forced against it, the oxygen will combine with the hot metal and burn it to an oxide. The resulting reaction generates an intense heat which is used in cutting. Since only the metal in the direct path of the oxygen jet is acted upon, the metal combines with the cutting oxygen and burns to an oxide. This heats the metal in the path of the oxygen jet to the melting temperature as the oxide passes down the side of the cut. This, in turn, is blown away on the opposite side of the cut leaving a narrow slot (kerf) separating the metal. When linear cutting, this kerf should be narrow and have uniformly smooth, parallel walls.

A skilled welder using a guided and controlled torch can make very accurate cuts. In many cases, they are suitable for the completed part with no other finishing required. The speed and economy with which iron and steel can be cut and shaped make the cutting torch an indispensable tool. Heavy sections which are uneconomical to cut by any other method are readily and smoothly cut with oxygen.

Although almost all metals readily combine with oxygen when they are heated to a high temperature, some of them cannot be successfully cut by this method. This is because their oxides have a higher melting point than the parent metal and mix with it instead of separating as they melt. The nonferrous metals, high chromium steels and cast iron do not cut easily, but they may be melted and blown away by high pressure oxygen. Low and medium carbon steel can be cut successfully by the oxyacetylene process without special preparation. High carbon steel parts must be preheated first. Ordinary tool steel requires a black heat while some alloy tool steels require a full red heat.

CUTTING EQUIPMENT

With the exception of the torch, the oxyacetylene cutting equipment is generally the same as the welding equipment. The oxygen regulators used for heavy cutting operations are designed to furnish a larger volume and higher pressure than is required for welding. The oxygen outlet is fitted

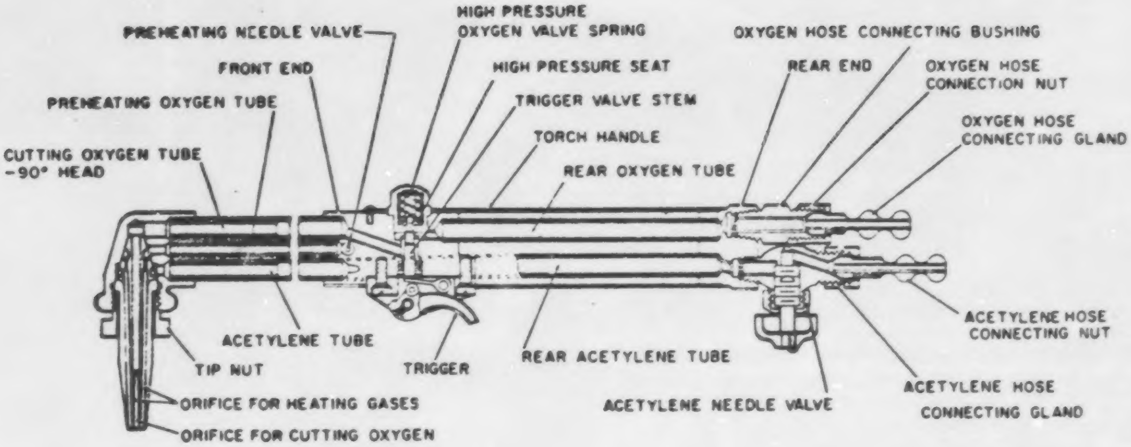

PREHEATING NEEDLE VALVE
HIGH PRESSURE OXYGEN VALVE SPRING
OXYGEN HOSE CONNECTING BUSHING
FRONT END
HIGH PRESSURE SEAT
REAR END
OXYGEN HOSE CONNECTION NUT
PREHEATING OXYGEN TUBE
TRIGGER VALVE STEM
TORCH HANDLE
OXYGEN HOSE CONNECTING GLAND
CUTTING OXYGEN TUBE -90° HEAD
REAR OXYGEN TUBE
ACETYLENE HOSE CONNECTING NUT
ACETYLENE TUBE
TIP NUT
TRIGGER
REAR ACETYLENE TUBE
ACETYLENE HOSE CONNECTING GLAND
ORIFICE FOR HEATING GASES
ACETYLENE NEEDLE VALVE
ORIFICE FOR CUTTING OXYGEN

Figure 58. Cutting Torch.

with a working pressure gage which is graduated to 400 psi. The oxygen hose is designed to withstand these high pressures.

Cutting Torch

The cutting torch mixes oxygen and acetylene in definite proportions, burns the mixture in preheating flames to heat the work and directs a jet of high pressure oxygen to sever the metal along the line of cut. The hand cutting torch is similar to a welding torch in appearance but differs in construction and method of control. It consists mainly of a handle, connecting tubes, and head, as shown in figure 58. The rear of the handle is equipped with oxygen and acetylene hose connections. The supply is controlled by a needle valve in the acetylene inlet connection. The oxygen furnished to the preheating flame is regulated by a preheat valve on the side of the handle. The cutting oxygen is controlled by a high pressure oxygen valve operated by a trigger or lever. In some cutting torches, the preheating oxygen and acetylene do not mix until they are in the cutting tip. These cutting torches have three gas tubes; one for high pressure oxygen, one for preheating oxygen, and one for acetylene. In other cutting torches, the preheating oxygen and acetylene premix in a common mixing chamber in the torch body. These torches have one gas tube for high pressure oxygen and one for the mixing of gases.

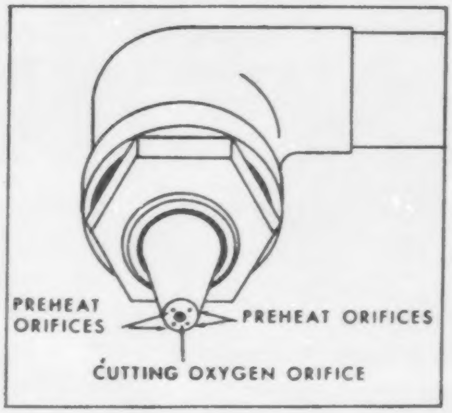
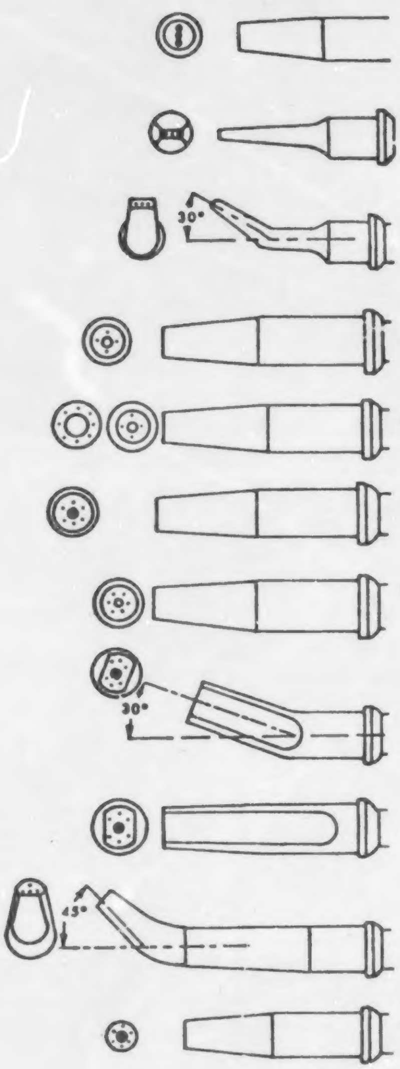

PREHEAT ORIFICES
PREHEAT ORIFICES
CUTTING OXYGEN ORIFICE

Figure 59. Cutting Tip.

Cutting Tips

The taper seated, separable cutting tip is held in the cutting torch head by the tip nut. The tip has a central orifice through which the cutting



NUMBER OF PREHEAT ORIFICES	DEGREE OF PREHEAT	APPLICATION
2	Medium	For straight line or circular cutting of clean plate.
2	Light	For splitting angle iron, trimming plate and sheet metal cutting.
2	Light	For hand cutting rivet heads and machine cutting 30 deg. bevels.
4	Light	For straight line and shape cutting clean plate.
4, 6, 8	Medium	For rusty or painted surfaces.
6	Heavy	For cast iron cutting and preparing welding V's.
6	Very Heavy.	For general cutting also for cutting cast iron and stainless steel.
6	Medium	For grooving, flame machining, gouging and removing imperfect welds.
6	Medium	For grooving, gouging or removing imperfect welds.
3	Medium	For machine cutting 45 deg. bevel or hand cutting rivet heads.
6	Heavy	Flared cutting orifices provides large oxygen stream of low velocity for rivet head removal (washing).

Most of the above cutting tips are available in two or more sizes and should be selected on the basis of the thickness of the metal and the job to be performed.

Figure 60. Some Common Cutting Torch Tips and Their Uses.

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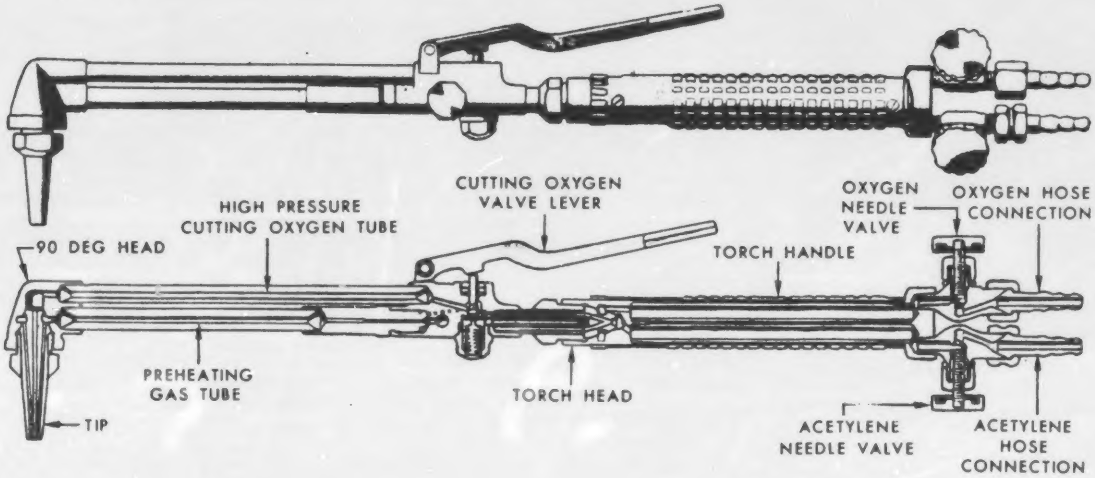
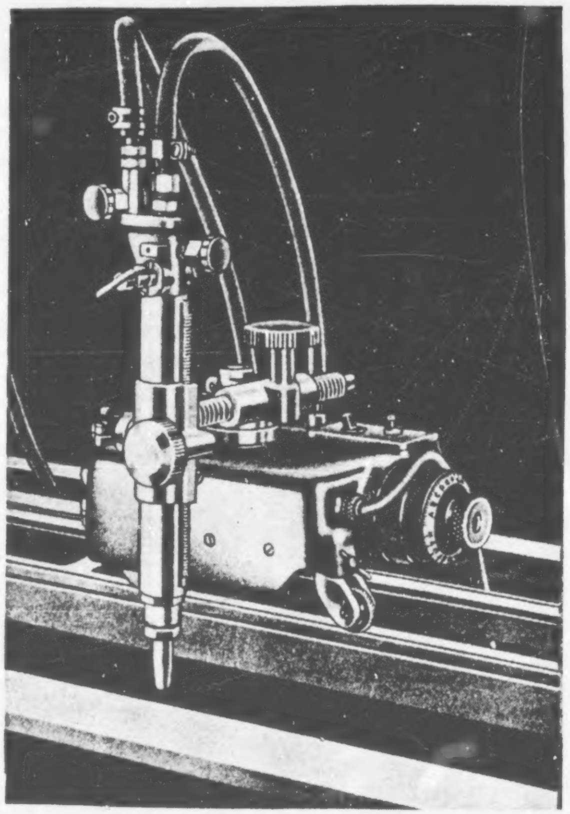

90 DEG HEAD
HIGH PRESSURE CUTTING OXYGEN TUBE
CUTTING OXYGEN VALVE LEVER
OXYGEN NEEDLE VALVE
OXYGEN HOSE CONNECTION
TORCH HANDLE
PREHEATING GAS TUBE
TORCH HEAD
TIP
ACETYLENE NEEDLE VALVE
ACETYLENE HOSE CONNECTION

Figure 61. Cutting Attachment for Welding Torch.

oxygen flows. This orifice is surrounded by several preheating holes, as shown in figure 59. Cutting tips with cutting and preheating orifices of various sizes are available for cutting practically any thickness of metal. Cutting tips are supplied in various lengths for special jobs. Bent tips are also used under certain conditions. Many special operations, such as flame machining, gouging, scarfing, and rivet cutting are done with cutting tips specifically designed for this purpose. Figure 60 shows these different designs.

Cutting Attachment

The construction and operation of the cutting attachment is similar to that of an ordinary cutting torch (figure 61). It is a simple attachment which fits the body of the standard welding torch and converts it quickly into a cutting torch. The changeover is made in a very short time since it is unnecessary to disconnect the hoses. This attachment is very useful for intermittent cutting and welding of lighter sections. The use of the cutting attachment is not recommended for constant cutting of heavy materials. Such work should be done with a regular heavy duty cutting torch.



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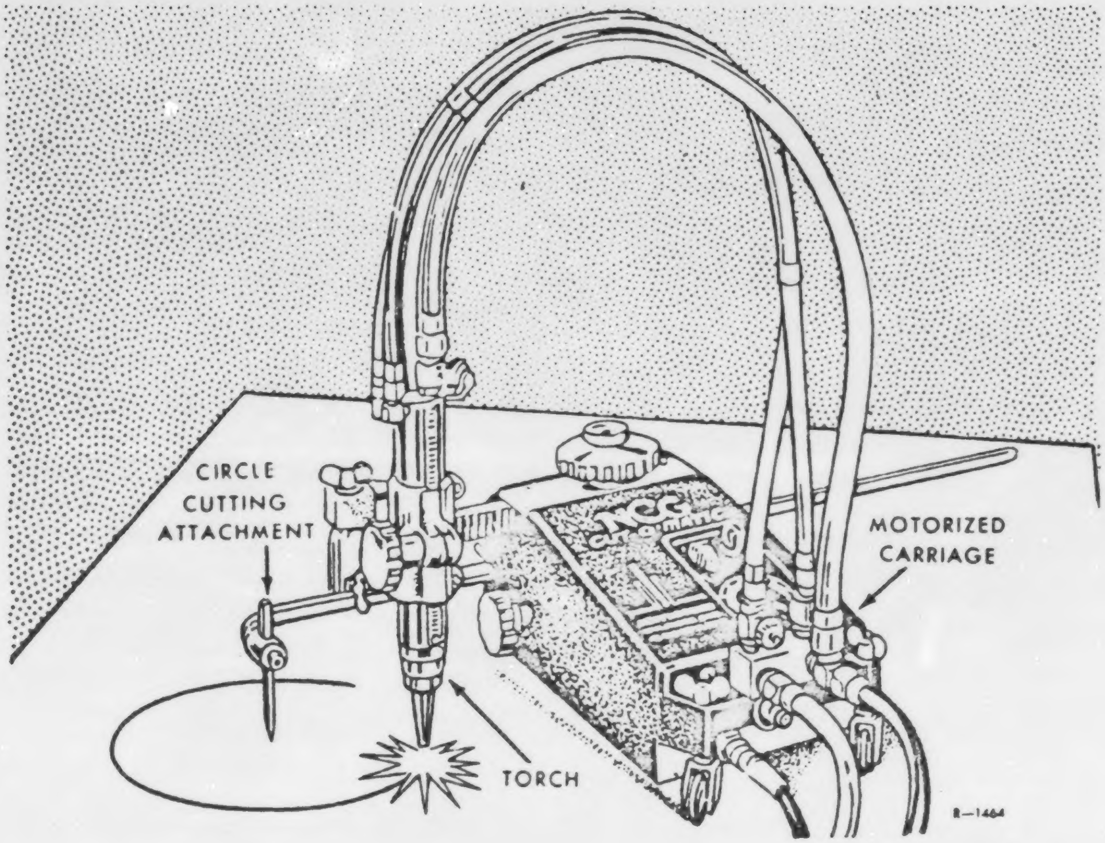

Figure 63. Electric Motor Driven Carriage Being Used to Cut Circle in Steel Plate. (National Cylinder Gas Co.)

Cutting Machine

Although many types of cutting machines are available and identified by various commercial trade names, they may be classified by their means of control and type of work they perform. Cutting machines have been improved by using electric solenoid valves to control the gas flow. Also, there are electronic and magnetic devices used for controlling torch movement. There are also machines which perform automatic cutting operations. These are special machines used for cutting; specific numbers of specially shaped objects a number of the same objects at the same time; straight kerfs; and for beveling metal. In order to make uniformly clean cuts on steel plate, motor-driven cutting machines are used to support and guide the cutting torch. Straight line cutting or beveling is done by guiding the machine along a straight line on steel tracks, as shown in figure 62. Arcs and circles are cut by guiding the machine with a radius rod pivoted about a central point, as shown in figure 63.

SELECTION AND MAINTENANCE OF CUTTING TIPS

Selection

The main factor in selecting the proper cutting tip size is the thickness of material to be cut. The correct style of cutting tip is determined by the type of material to be cut, type of cut, and surface condition. Some materials are more difficult to cut than others and require different cutting tips. Since cutting depends on oxidation, the metal should be cleaned before it is cut. Rust, scale, or painted surfaces offer greater

2

Plate Thickness	Tip Size Nr	Acetylene Pressure, lbs per sq inch	Oxygen Pressure, lbs per sq inch
1/4 in	0	3	25 to 30
3/8 to 1/2 in	1	3	30 to 40
3/4 to 1 in	2	3	40 to 50
1 1/2 in	3	3	45 to 50
2 in	4	3	50 to 55
3 to 4 in	5	4	55 to 65
5 to 6 in	6	5	55 to 60
8 to 10 in	7	6	60 to 70
12 in	8	6	70 to 80

Table 5. Recommended Pressures for Cutting Low Carbon Steels.

resistance to the preheating flame. The tip size and oxygen and acetylene pressures generally used for cutting steel plates of various thickness are listed in Table 5. Specific information on cutting pressures and cutting speeds for a given thickness of material is furnished by the manufacturer of cutting torches. It is uneconomical to use oversize cutting tips and excessive oxygen and acetylene pressures. A cutting tip with a large cutting oxygen orifice produces a wider kerf than necessary and consumes more oxygen than a tip with a smaller orifice even though lower oxygen pressure is used. Excessive oxygen pressure causes the cutting jet to swirl and spread out after leaving the tip. This produces a wide kerf with uneven sides and increasing oxygen consumption. For maximum efficiency, cutting tips should be operated at normal capacity but not beyond.

Maintenance

Good cutting results also depend on an accurately shaped flame. The accumulation of slag and oxide on the cutting tip, figure 64, causes the preheating flames to be irregular in shape and causes the top edge of the cut to be jagged. The procedure for cleaning cutting tips is as follows:

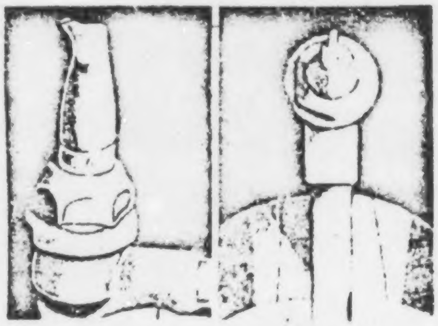

Figure 64. Accumulation of Slag on Cutting Tip.

1. Fasten the torch in a vise, as shown in figure 65. Use a soft material or block of wood on the face of the jaws to prevent damage to the torch tubes.

2. Wrap a piece of fine emery cloth around a file and clean the end of the tip, as shown in figure 66.

3. Select a tip cleaner two sizes smaller than the size of the tip orifice and clean by moving the tip

2

2

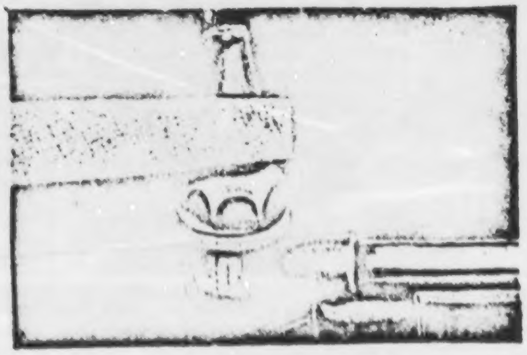

Figure 65. Hold Torch in Vise.

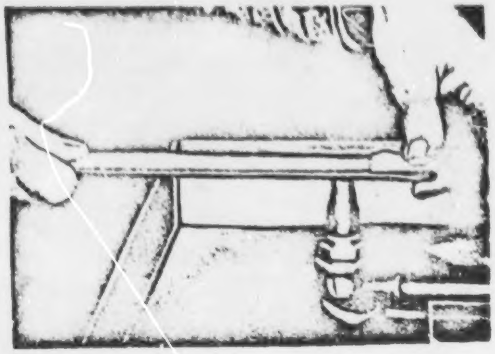

Figure 66. Removing Slag Using Fine Emery Cloth on File.

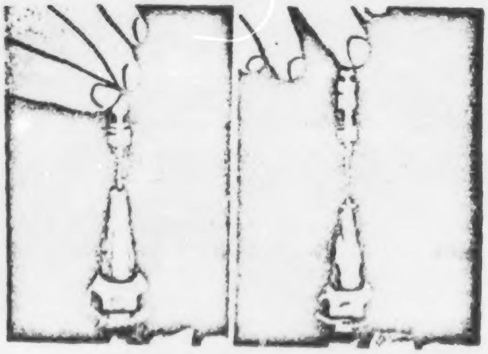

Figure 67. Cleaning Orifices With Tip Cleaner.

cleaner up and down, as shown in figure 67. DO NOT TWIST. If tip cleaners are not available, use a soft copper wire.

The preheating flame should be of uniform shape and length. A flame of this type helps to ensure a smooth cut.

CUTTING PROCEDURE

Plain carbon steel whose carbon content does not exceed 0.35 percent can be cut without special precautions other than those required for cuts of good quality. For higher carbon steels, care must be taken to prevent the formation of a hard layer at the edge of the plate. In order to avoid this, the plate edges are preheated in advance of the cut. Preheating temperatures of 500°F to 600°F should be used in cutting steels in this class.

To cut carbon steel, first adjust the preheating flame to neutral with the torch needle valves, then open the cutting oxygen valve and readjust the flame to neutral. The flame heats the metal to the melting temperature and the rapid oxidation separates the metal.

The procedure for setting up a cutting outfit is the same as for a welding outfit and must be followed carefully. The procedure for closing down the cutting outfit is the reverse of setting up. Since much higher oxygen pressures are used in cutting, it is important to release the adjusting screw to relieve the working pressure when the outfit is not in use.

Straight Line Cutting

In straight line cutting, clearly mark the line of cut with a center punch or a guide bar clamped into position to guide the torch accurately, as shown in figure 68. To start the cut, hold the torch perpendicular to the work with the inner cone of the preheating flame slightly above the surface of the metal, as shown in figure 69. When a red heat has been reached, open the cutting oxygen valve slowly until it is fully open. If the cut has been started properly, a shower of sparks should fall from the other side, indicating that the cut has penetrated

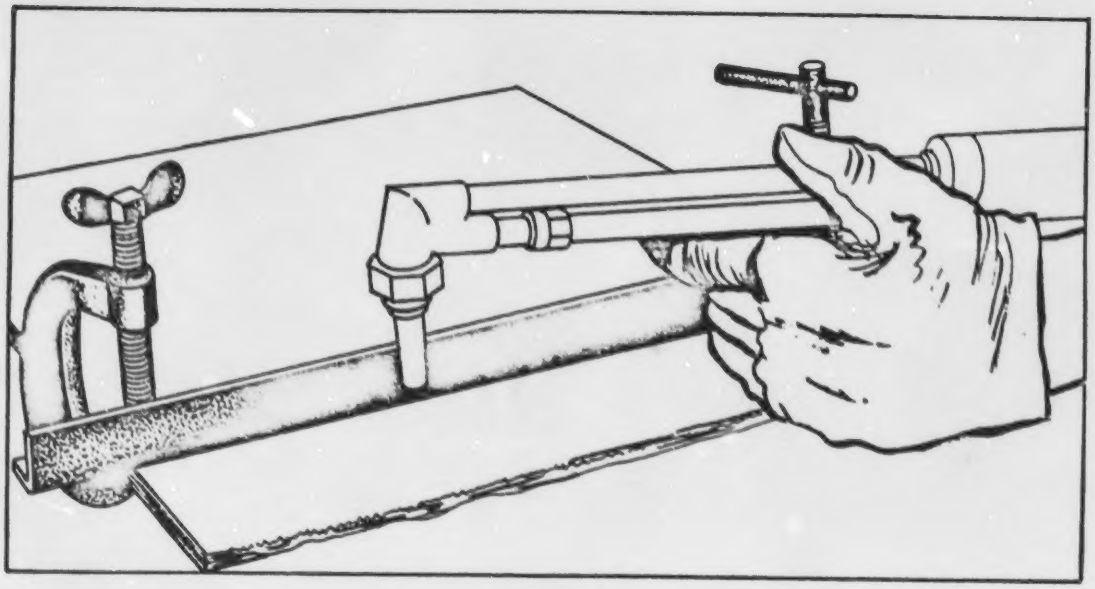

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Figure 68. Straight Line Cutting.

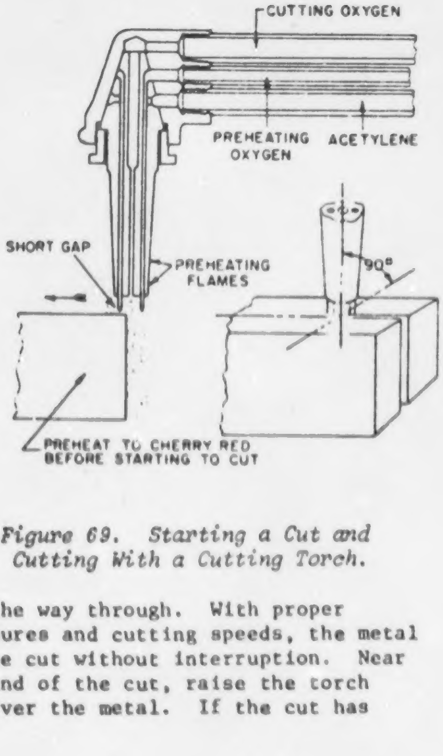
CUTTING OXYGEN
PREHEATING OXYGEN
ACETYLENE
SHORT GAP
PREHEATING FLAMES
90°
PREHEAT TO CHERRY RED BEFORE STARTING TO CUT

Figure 69. Starting a Cut and Cutting With a Cutting Torch.

all the way through. With proper pressures and cutting speeds, the metal can be cut without interruption. Near the end of the cut, raise the torch to sever the metal. If the cut has been made properly, the result will be a clean, narrow kerf comparing favorably with one made by sawing. If the speed is too fast, the metal may not be preheated sufficiently to continue the cut. To restart, direct the flame slightly behind the point at which the cut was lost. Resume the cut when the metal is preheated properly.

Circular Cutting

Circular cutting with a hand held cutting torch is done with a circular cutting attachment shown in figure 70. This attachment consists of a rod with a clamp attached to one end which fits the torch head. An adjustable center point on the bar may be set to the desired radius. When the cut must be started away from the edge of the metal, a small hole may be drilled or burned through the metal a short distance from the circular outline and the cut started from the edge of the hole.

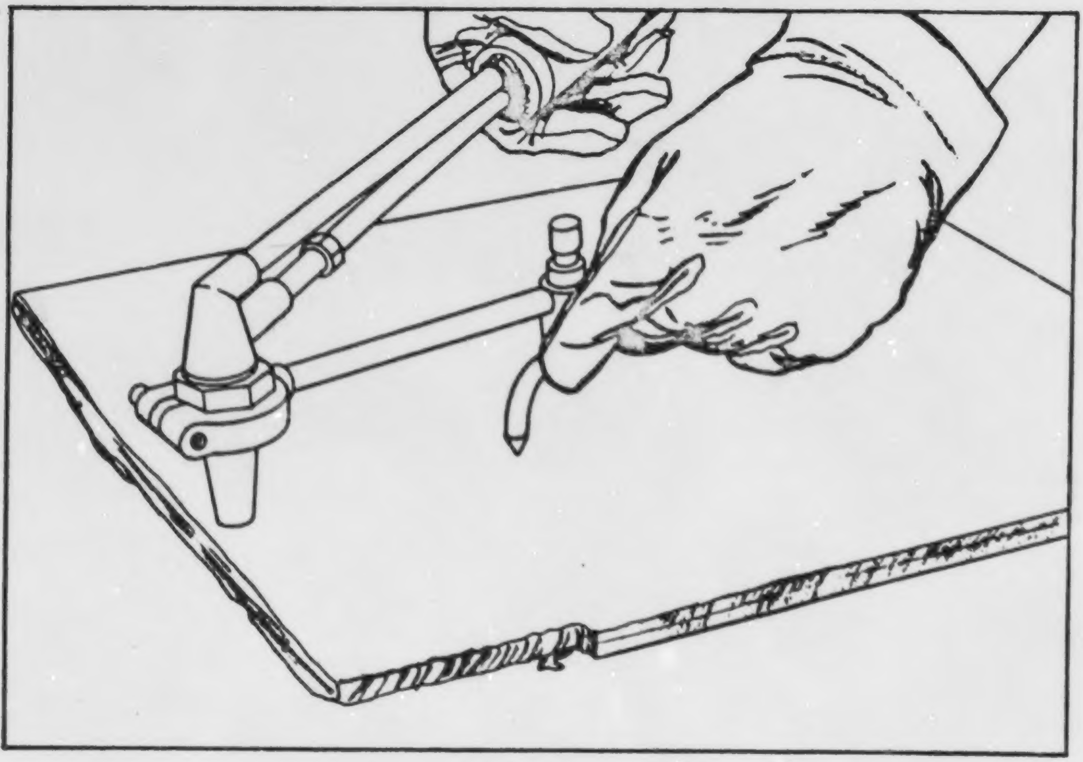

Figure 70. Circular Cutting Attachment.

Piercing

More time is required in hole piercing than is with edge starting. When the spot is sufficiently heated, raise the torch about 1/2 inch above the normal position for cutting, then open the cutting oxygen valve. After burning through, lower the torch to the normal height above the work and complete the cut. Care must be taken to prevent slag from plugging the cutting orifice. This occurs if the torch is held too close to the work when first opening the cutting oxygen valve.

Beveling

Torch control during beveling is more difficult than straight square edge cutting. The speed at which the torch is moved and the steadiness of the movement are important in obtaining a smooth cut. A line indicating the top edge of the bevel may be made with chalk. A straight edge clamped into position may be used as a rest to assist in maintaining the proper torch angle. The angle which the cutting oxygen makes with the surface of the metal produces the desired bevel.

SAFETY PRACTICES

In all cutting operations, special care must be taken to prevent damage to equipment and injury to personnel from fire and explosion. The high cutting oxygen pressures may blow sparks a considerable distance. Extreme care must be taken when cutting an enclosed container. Even though empty, flammables may remain in the seams of containers for a long period of time, give off fumes from heating, and explode. Flammable materials within the range of flying sparks must be moved to a safe distance. The following rules must be observed in the safe operation of cutting equipment.

1. Never dismantle or salvage magnesium parts with an oxyacetylene cutting torch.

2. Never cut used drums, tanks, or other containers until they have been thoroughly cleaned. If steam is to be used, a minimum of three hours is required for cleaning. Flushing with hot water for one hour is permissible but not recommended unless absolutely necessary. Cutting should be performed as soon as possible after cleaning.

3. Combustible material must be moved to a safe distance or the work moved to a safe location away from such materials. Asbestos or sheet metal guards may be set up when needed.

4. Do not cut material in a position that permits sparks, hot metal, or the severed section to fall on the oxygen and acetylene cylinders, hoses, or on your legs and feet.

5. Always wear adequate clothing, such as high top shoes, gloves, and clothing without cuffs. Cuffs may collect hot metal and cause a serious burn.

6. Use a fire guard when the nature of the work requires one.

7. When cutting is to be stopped for short periods, release the regulator adjusting screw. The complete outfit should be closed down when you leave the vicinity of the job for any length of time.

PROCEDURE

1. Select a tip size for the thickness of metal to be cut as recommended by the torch manufacturer.

2. Adjust the oxygen gage to the proper working pressure with the torch oxygen valve all the way open. Refer to Table 5.

3. Adjust the acetylene gage.

4. Open the torch acetylene valve and light the acetylene.

5. Open the low pressure oxygen valve and adjust it to a neutral flame.

6. With the cutting lever depressed, open the cutting oxygen valve and readjust to a neutral flame.

7. Direct the preheating flame about 1/16" from the metal where the cut is to begin and heat to a bright red. DO NOT MELT.

8. Depress the cutting oxygen lever and move the torch along the predetermined line of cut at a uniform rate of speed.

9. Continue cutting until satisfactory results are obtained.

10. Check with your instructor periodically.

Precautions

1. Make sure the metal on both sides in line with the cut is free from scale, heavy rust deposits, or any other nonoxidizable material.

2. Check the torch tip orifices to make sure they are clean.

3. Make sure there are no gas leaks in the apparatus.

4. See that flammable materials or substances are a safe distance away.

5. Protect your feet and legs from the hot slag and falling metal.

6. Always wear close fitting goggles when you are cutting.

7. Keep the hoses clear of falling metal and slag.

8. Do not wear cuffs on your trousers.

9. Make sure there is a properly charged fire extinguisher nearby.

QUESTIONS

Note: Due to the conservation of paper, answer all questions on a separate sheet of paper. DO NOT WRITE IN THIS STUDY GUIDE.

1. When cutting thin sheet metal, how should the cutting torch be held in relation to the work?

2. What is the approximate torch angle for oxyacetylene cutting of material over 1/2 inch in thickness?

3. Special cutting precautions need not be taken when cutting plain carbon steel if the carbon content does not exceed a certain percentage. What is this percentage?

4. During the process of cutting carbon steel, how far should the torch tip be from the material?

5. What is the main factor in determining the size of tip for oxyacetylene cutting?

6. What is the narrow slot that is caused by oxyacetylene cutting?

REFERENCES

1. TO 34W4-1-5, Welding Theory and Application.

2. Modern Welding Handbook (Chapters 3 and 15).

Metal and NDI Branch
Chanute AFB, Illinois

3ABR53131-SG-205

SILVER AND LEAD SOLDERING

OBJECTIVES

After completing this study guide and your classroom instruction, you will explain and apply the techniques and procedures of silver and lead soldering various types of joints and combinations of metals using the oxyacetylene welding torch.

INTRODUCTION

Soldering is used for joining most common metals with an alloy that melts at a temperature below that of the base metal. In many respects, this operation is similar to brazing. The soldered joint depends on the penetration of the solder into the pores of the base metal surface and the formation of a base metal solder alloy, together with the mechanical bond between the parts.

INFORMATION

MANAGEMENT OF DEFENSE ENERGY RESOURCES

Due to the conservation of energy resources, do not write in or mark on any training literature since it will be reused by other classes. Lights will be turned off any time the classroom is vacant for more than 20 minutes. All consumable materials will be used conservatively throughout Block II.

SILVER SOLDERING

Silver soldering is a process in which bonding is produced by heating the base metal to a temperature between 1175°F and 1600°F and adding a silver alloy filler metal with a melting point within this temperature range.

Joints which permit capillary action are best suited for silver soldering because of the high strength obtained. Less heat is required since the silver alloy filler metal flows at a low temperature. The advantages of silver soldering are: the low temperature used avoids heating the metal to temperatures at which physical properties or other qualities are impaired, distortion is held to a minimum, procedures and techniques are quite simple, and the process may be completed quite rapidly. Silver alloy filler metals are used for joining virtually all ferrous and nonferrous metals. The exceptions are aluminum, magnesium, and several other low melting point alloys and metals.

The strength of a silver soldered joint depends on the fitup and quality of the bond between the filler metal and the base metal. The heat opens the crystal grain structure and allows the filler metal to penetrate along the grain boundaries on the surface of the base metal. This creates a physical bond between the filler metal and the base metal. It is this bond that produces the high strength of a soldered joint. No fusion takes place between the filler metal and the base metal. Parts that are silver soldered should not be used when they are subjected to temperatures that exceed 500°F. At 500°F, the silver solder bond becomes weak, loses strength, and becomes progressively weaker as the temperature increases.

There are numerous applications in which silver solder is used in the fabrication of aircraft parts, especially those in which high electrical and thermal conductivity is desired. Typical examples are the fabrication of aircraft radio shields, instrument fittings, copper oil and fuel lines, and inlet and outlet connections on some radiators and oil coolers.

Silver solder can be obtained in several grades with a silver content ranging from 10 to 80 percent and with a melting point from 1160°F to 1500°F. It comes in rod, strip wire, and granulated form. The strip or ribbon form is generally used for fixed setups in which the solder can be placed in the joint before heat is applied. The rod and wire forms are primarily used for joints where it is preferable to apply the solder by hand.

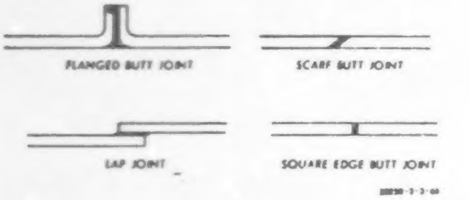

Figure 71. Recommended Joints for Silver Soldering.

Joint Design

Several factors influence the type of joint to be used; the most important are the type of base metal and the service requirements of the joint. The type of joint is an important factor since the preparation, fitup, and results obtained differ from those in welding. Silver solder flows freely into narrow openings. The strongest joints are obtained by using small clearances between 0.002 and 0.005 inch.

Two basic types of joints are used in silver soldering, the lap and the square edge butt. The butt joint may be modified to include the flanged butt joint and the scarf butt joint, as shown in figure 71. The lap joint is most commonly used since it permits capillary action and is the strongest, see figure 72. Maxmimum efficiency is obtained when the overlapping of the base metal equals or exceeds three times the thickness of the thinnest section of the base metal.

Joint Preparation

The surface must be clean and free of oxides to ensure uniform quality and a sound soldered joint. All grease, oil, dirt, and oxides must be removed from the base metal and the filler rod to ensure uniform capillary action throughout the joint. Soldering should be done as soon as possible after the base metal and filler rod have been cleaned.

The method of cleaning is normally either mechanical or chemical. Some of the mechanical methods are: sandblasting, grinding, buffing, vapor degreasing, filing, and scraping. Some of the chemical methods are: acid pickling, alkaline cleaning, and electrocleaning. Before using chemical cleaners, the metal must be washed clean to remove any undesirable residue since it may attack the base metal or form a film on the surface. Any chrome, cadmium, paint, lacquer, or other coating should be removed prior to soldering since the solder must make contact with a clean surface of the base metal.

Flux

Chemical reaction occurs in metals when they are exposed to air or special environments. Most metals are unstable in their pure form and tend to revert to the more stable compounds in which they are found in nature. The rate of chemical reaction generally increases as the temperature rises.

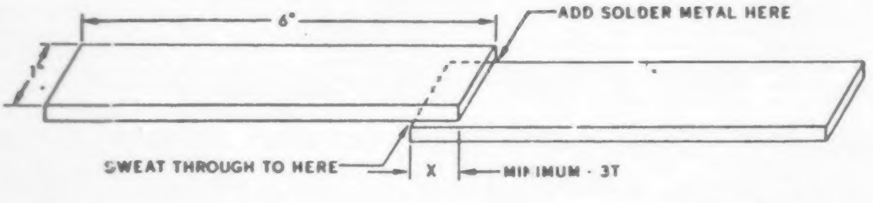

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Figure 72. Lap Joint.

An increase of moisture in the atmosphere further increases the rate of the reaction. The formation of oxides and other compounds on the surface of the metal inhibits the uniform flow and wetting of the molten solder, resulting in nonuniform bonding and poor joint strength. The use of flux counteracts these adverse effects.

Flux aids in making strong, uniform soldered joints and is essential in silver soldering. A good flux performs the following functions:

1. Reacts with surface films, such as oxides to reduce them and enable the metal to present clean surfaces to the molten silver alloy.

2. Forms protective films during the soldering cycle to prevent reoxidation at the elevated temperatures required for soldering.

3. Assists the silver alloy in flowing freely.

The use of flux does not alter the need for cleaning parts prior to silver soldering. Flux supplements the initial cleaning by dissolving, inhibiting, or rendering ineffective those products which impair the quality of the joint or prevent bonding.

Flux comes in a variety of forms, such as powder, paste, liquid, or solid coating applied to the silver alloy filler metal. The flux must be removed after the soldering is completed. Trapped flux can weaken or corrode the soldered joint. Flux can usually be removed from parts by washing them in hot water.

If the joint can withstand a moderate thermal shock, the flux can easily be removed by immersing it in water while it is still warm. Several good ready-mixed fluxes are available commercially but the following may be used as substitutes: an equal mixture of borax and boric acid for copper, brass, bronze, and monel metal and a mixture of three parts boric acid and one part borax for steel. Flux may be applied in powder form or dissolved in water and applied with a brush. The temperature at which the flux begins to flow freely may be used as an indication of the proper temperature for applying the solder.

Torch Technique and Flame

Depending upon the gas mixtures, four different types of torches are commonly used for silver soldering: air-gas, air-acetylene, oxyacetylene, and oxyhydrogen. Air-gas torches provide the lowest flame temperatures as well as the least heat, depending on the size of the torch. The torch should be of sufficient size and capacity to allow the use of a neutral or slightly carburizing flame. Oxyacetylene torches provide the highest flame temperatures. These torches have been perfected to a high degree and, if properly used, offer the most flexible and versatile method of heating.

The tip size used depends on the thickness of the base metal. Do not let the inner cone of the carburizing flame touch the metal. This causes the filler metal to be sluggish at the flow point and the flux to be burned, reducing its efficiency in promoting the flow of solder through the joint. The torch should be kept in motion all the time, since holding it in one place too long can very easily overheat the base metal and the flux. If a part is over-heated and the capillary flow of solder is hindered, the part must be recleaned and all oxides and foreign matter removed. Low heat and cleanliness are very important in silver soldering.

In soldering large metal surfaces, the metal should be preheated well away from the joint, especially when the metal has a high heat conductivity. Care must be taken in soldering metals of unequal thicknesses or unequal heat conductivity since it is necessary for both parts to reach the soldering temperature at the same time. Forming of a small fillet at the face of the joint is the indication of complete bonding through the joint.

A soft, neutral to slightly carburizing, flame should be used. A clean tip is always important, especially on fine work since the flame on a dirty tip may angle off to one side, making it harder to direct the heat to the proper spot.

Silver Soldering Procedure

1. Using the proper procedures, clean the metal and filler rod.

2. Apply the flux to the rod and to the inner surface of the joint.

3. Select and install the proper size torch tip.

4. Set up work, as shown in figure 71.

5. Adjust the flame to a soft neutral or slightly carburizing, flame and preheat the base metal, keeping the torch in motion at all times.

6. When the proper temperature is reached, apply the rod and sweat the solder through the joint.

7. Allow the soldering alloy to solidify before moving the work.

8. Quench and remove the flux.

9. Check with your instructor for fitup, bonding, and capillary flow through the joint.

Precautions

1. Make sure that the base metal and rod are cleaned to a bright surface and are properly fluxed.

2. Heat the joint using the outer flame only and keep the torch constantly in motion.

3. Do not use the inner cone of the flame to melt the filler rod.

4. Be especially careful not to overheat the base metal.

LEAD SOLDERING

The lead soldering process is the same as silver soldering except that bonding is produced at temperatures below 800°F. Cleaning and joint design are basically the same as for silver soldering. Fluxing and flux removal are different in that the type of flux used is only for lead soldering and the removal of flux is not always necessary.

Joints should be designed with the requirements and limitations of the solder in mind and shaped so that they fit together properly. A joint that permits capillary action is best suited for lead soldering.

The metal surfaces must be cleaned as thoroughly as possible before joining to ensure proper bonding between the base metal and the solder. Cleaning may be done by chemical or mechanical methods.

Flux is applied to the precleaned surface to remove the last traces of surface film. It also prevents the formation of new surface film before and during the soldering. The ease with which the base metal solders is often indicated by the mildness of the flux that can be used. As the metal becomes more difficult to solder, it is necessary to increase the activity of the flux or resort to special fluxes and solders. Some metals are so difficult to solder that it is wise to consider some other method of joining.

The residue must be removed when a corrosive flux has been used. With a noncorrosive flux, removal may be necessary if the appearance of the joint is important or if some organic coating, such as paint or lacquer, is to be applied.

The parts to be joined are positioned so that movement cannot take place during the heating and cooling. The same torch that is used for silver soldering can be used for lead soldering. If available, a soldering iron is best for small, thin materials. A neutral or slightly carburizing flame should be used.

Procedure of Lead Soldering

1. Using the proper procedures, clean the metal.

2. Apply flux to the joint.

3. Set up the work as demonstrated by the instructor.

4. Install a small size torch tip and adjust the flame to a soft neutral.

5. Use only the outer envelope of the flame for preheating and soldering.

6. Allow the solder to solidify before moving the work.

7. Quench and remove the flux.

8. Check your work with the instructor.

Precautions

1. The base metal must be clean.

2. Use only the outer envelope of the flame.

3. Use a very soft, neutral flame to prevent overheating.

QUESTIONS

Note: Due to conservation of paper, answer all questions on a separate sheet of paper. DO NOT WRITE IN THIS STUDY GUIDE.

1. Explain the tinning process.

2. What does the strength of a lap joint depend upon?

3. What is the maximum clearance for the greatest strength of a silver soldered lap joint?

4. Why should parts that have been silver soldered not be subjected to temperatures higher than 500°F?

5. What is the melting point range for silver solder?

6. What will lower the melting point of silver solder?

7. What determines the strength of a silver soldered joint?

8. What metals or alloys cannot be silver soldered?

9. Define bonding.

10. What is the maximum bonding temperature for lead solder?

REFERENCES

1. TO 34W4-1-5, Welding Theory and Application.

2. Modern Welding Handbook (Chapter 15).

MODIFICATIONS

Pages 71- 111 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

BRAZING STEEL AND GRAY IRON CASTINGS

OBJECTIVES

After completing this study guide and classroom instruction, you will be familiar with the properties produced by brazing ferrous castings and carbon steel. You will also apply the techniques of brazing steel and gray iron castings.

INTRODUCTION

Brazing is a method of joining metals together without fusion. The melting point of a brazing alloy, like that of a soldering alloy, must be below the melting point of the metals to be joined.

INFORMATION

MANAGEMENT OF DEFENSE ENERGY RESOURCES

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CAST IRON

Cast iron is a product of the cupola furnace. The type of cast iron produced is determined by the rate of cooling from the molten state. Cast iron always contains more than two percent carbon. In fact, cast iron is defined as iron with a carbon content of more than two percent. Because of this high carbon content, some of the carbon combines with the iron to form free iron carbides. This results in a brittle metal which is unfit for highly stressed structural parts. Cast iron in the molten state is very fluid and solidifies slowly, making it possible to produce castings of intricate designs. The tensile strength of cast iron is low compared to steel. It will fail under excessive loads and shock with little or no bending nor permanent set. Its compression strength is high.

Gray Cast Iron

If the iron is cooled slowly, the result is a soft gray colored metal called gray cast iron. It can be machined easily but will not withstand heavy shock. It is malleable at any temperature. Gray cast iron is used for cylinder blocks of automobile engines, pump bodies, gears, pulleys, and other applications in which weight and rigidity are required without great strength. When it is broken, the fractured surface is dark gray in color. This is the only cast iron that can be repaired by fusion welding.

White Cast Iron

If the iron is cooled rapidly from the molten state, the result is a hard and brittle metal called white cast iron. This iron is used for parts which require abrasion resistant surfaces but do not require high strength, shock resistance, or similar mechanical properties. When it is broken, the fractured surfaces are silvery-white in appearance. The only method of repair is brazing.

Malleable Cast Iron

This metal is produced by heating white cast iron to about 1650°F., holding it at this temperature for several hours or days and then cooling it slowly. Malleable iron castings can be bent slightly without breaking because the carbon is uncombined and is distributed throughout the metal in rounded globules which act like a lubricant. They are used for hard-wearing handtools, automotive parts, and other parts which must withstand shock. When it is broken, the fractured surface is like gray cast iron but is a dull gray in color and somewhat lighter. The best method of repair is brazing.

IDENTIFYING CASTINGS

Spark Test

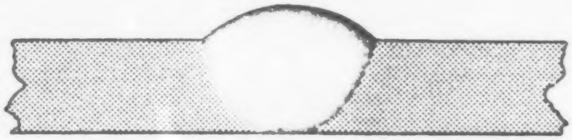
Ferrous castings can be identified by the characteristics of the spark stream generated by bringing the metal into contact with a high speed grinding wheel. The part should be touched lightly to the wheel and the characteristics of the spark stream carefully checked. The spark stream of metals varies in one or more of the following: color, density, shape, and length. Considerable experience is necessary to identify cast iron by this method. Positive identification can be made by comparing the spark streams of an unknown metal with those of a known metal.

Chip Test

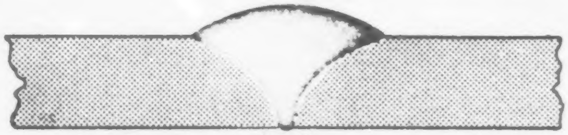
The chip test is often used to distinguish one type of casting from another. A narrow chip is cut from the part with a chisel. The ease with which the metal can be chipped and its form is a means of identification. When gray cast iron is chipped, the chips will break loose with each blow of the hammer. The groove produced will be smooth with a gray appearance. White cast iron is very hard and cannot be cut or chipped with a chisel. Fractured surfaces have a silvery-white appearance. The chips from malleable cast iron are similar to those of steel on the outer surface but when this surface is penetrated, the chips show a white steely skin. The center of the casting appears gray as in gray cast iron.

BRAZING CAST IRON

The brazing of gray cast iron is often preferred to welding by the fusion method. This process may be used to repair broken or cracked cylinder blocks, cylinder heads, and machine castings. Further applications are the building up of worn surfaces, broken or work gear teeth, and in the fabrication of cast iron pipe. The advantage in brazing cast iron is the low heat needed to do it properly. The casting does not require extensive heating and, in some cases, the parts may be brazed without disassembly. The deposit and adjacent metal are always soft and expansion and contraction are reduced to a minimum. Castings which are used for parts subjected to a high temperature must not be brazed since the strength of the deposit is reduced at temperatures above 650°F.



FUSION WELD



BRAZE

Figure 83. Fusion Welding and Brazing a Butt Joint.

The joint design and the technique used in brazing are the same as in fusion welding with the important exception that the base metal is not melted. The bond is physical rather than chemical as in fusion welding, as shown in figure 83. The filler rod used provides reinforcement of the joint.

The fact that brazing is done without melting the base metal greatly simplifies the repair procedure. It is much easier to make sound joints even in intricate castings by this method. Brazing requires less heat than fusion welding and the speed is faster with a corresponding decrease in time and gas consumption for a given job.

The lower temperature required in brazing simplifies preheating. The metal is preheated to a black heat and, as a result, the effects of expansion and contraction are much less than in fusion welding. Most brazing operations can be done with only local preheating.

Brazing is also the only practical method of repairing malleable iron castings. Malleability is developed by a special lengthy heat treatment which would be destroyed by the high temperatures required in fusion welding. The relatively low temperatures used in brazing do not greatly affect the malleable properties of the casting.

Bronze Filler Rod

A bronze filler rod is used in brazing. Bronze yields readily as it cools until the temperature is below 500°F. It yields slowly under reasonably low stresses even at room temperatures. This yielding does not weaken the deposited bronze metal but materially reduces the locked up stresses in a casting which has been brazed. The ductility of the bronze acts further to take up minor stresses during subsequent use of the part.

The filler rods are made of copper alloys which contain approximately 60 percent copper and 40 percent zinc. This proportion produces the best combination for high tensile strength and ductility. Other rods contain small quantities of tin, iron, manganese, and silicon. The addition of these elements makes them free flowing, deoxidizes the weld metal, decreases the tendency to fume, and increases the hardness of the deposited metal for greater wear resistance.

Brazing rods are manufactured in 1/32, 1/16, 1/8, 3/16, and 1/4 inch diameters. The rods melt at about 1625°F., flow freely, and do not fume to any extent at brazing temperatures.

Joint Preparation

In brazing cast iron or steel with bronze, the metal in the area of the braze must be thoroughly cleaned to remove all scale, rust, grease, and oil. The parts should be beveled and all sharp edges or corners ground off to give round edges and a smooth surface. The joints in figure 84 will develop the highest strength because of the area of the bond between the bronze and the base metal is greater than that obtainable with the ordinary 90° bevel. The V bevel shown in figure 84A may be made by grinding. It will develop the full strength of the metal and should be used when high strength is required. The U joint shown in figure 84B may also be prepared by grinding. In large castings, the groove can be made with a pneumatic chipping hammer. A portable grinder with a wheel shaped to produce the desired shaped groove may also be used. After the edges to be brazed are cleaned and beveled, the surfaces should be sandblasted or seared to remove the free graphitic carbon from the surfaces. To sear the edges, an oxidizing flame is moved along the surface of the joint with the central cone touching the metal. The free carbon combines with the excess oxygen in the flame and leaves the iron free of graphitic carbon so that a better bond may be obtained.

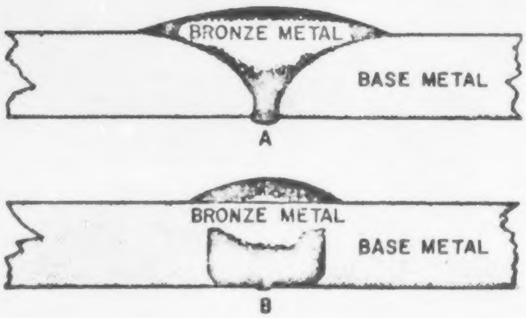


Figure 84. Recommended Types of Joints for Brazing Cast Iron.

Flux

The use of flux is essential in brazing cast iron using the oxyacetylene process. Commercial flux is available in powder and paste form. The flux should be applied either by dipping the hot end of the rod in the powder or brushing the paste on the rod. In brazing, liberal use of the flux should be made in the tinning operation. In filling the vee, flux should be used sparingly to avoid too much reduction of the oxide film covering the molten pool.

Flame Adjustment

The flame should be slightly oxidizing to tin cast iron and must be large enough to raise the metal quickly to a full red heat where the braze is to be started. The purpose of using an oxidizing flame is to free the graphitic carbon that comes to the surface as the metal is being heated to the brazing temperature. The free carbon combines with the excess oxygen in the flame and burns away leaving the surface clean. After the tinning coat is applied, the flame should be adjusted to neutral to prevent oxidation of the metal. The torch tip used should be about one size larger than that used for fusion welding steel of the same thickness.

Torch Application

The flame should be applied slightly behind the point of rod application until the area reaches a full red heat. During the application the bronze should spread quickly and tin the heated area if the edges have been properly cleaned and flux applied. The molten pool should be made small at the bottom of the vee and increased in size as it is moved forward until it completely fills the vee and a full size braze has been made. Care should be taken to ensure that the tinning action takes place continuously just ahead of the molten pool. The proper brazing technique consists essentially of combining into one continuous operation the tinning action and the building up of the braze to the desired size. In brazing heavy material, it is frequently necessary to deposit the bronze in layers. In such cases, make certain that the base metal is well tinned as the first layer is applied. This assures a strong bond for applying the succeeding layers.

In applying the bronze, hold the central cone from 1/8 to 1/4 inch from the surface of the metal. Point the flame ahead of the deposit at an angle of about 45° with the molten pool slightly behind the tip of the flame. This angle may vary depending upon the position and thickness of the metal being repaired. The manipulation of the torch and filler rod depends largely upon the size of the molten pool carried and the speed of brazing.

Careful attention is required in applying bronze to cast iron to obtain a good bond between the metals. If the base metal becomes too hot, the bronze balls up and fails to stick to the cast iron. Excessive fuming indicates overheating and a loss of zinc in the filler metal. If the metal is not heated to the proper temperature, the bronze will not spread and adhere to the casting. Excessive use of flux should be avoided; use only enough to secure a good tinning action. The end of the filler rod should be placed in the outer flame envelope, heated, then dipped into the dry flux powder and placed in the molten pool. A sufficient amount of flux will adhere to the rod for each application.

The proper brazing speed is indicated by the speed of tinning and contour of the deposit. The bronze should not be applied faster than the tinning action progresses.

In brazing a crack/break that terminates in a hole/opening in a casting, the braze should progress towards the point of termination. When brazing long joints on flat surfaces, the braze should progress from the ends toward the middle. When brazing branch cracks, the braze should start at the end and progress toward the main break. It is a good practice to drill a small hole at the end of the crack or break to permit stresses, caused by expansion, to be distributed around the circumference of the hole, thus preventing the fracture from spreading.

Heavy sections are brazed by successive deposits which start at the bottom of the vee and build up the weld to the proper height. Occasionally, some impurities are trapped in the molten pool and a blow hole appears as the metal solidifies. These impurities should be removed as

PROCEDURES

1. Brazing Cast Iron

a. Bevel the edges, as shown in figure 78.

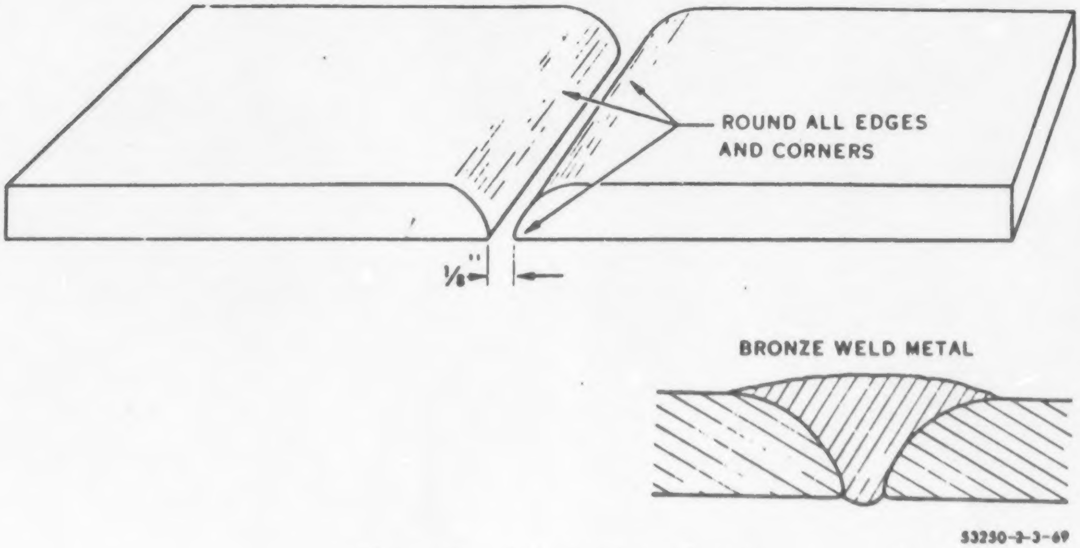


Figure 85. Butt Joint in Cast Iron.

the braze progresses by melting the metal beneath them and raking them out with the filler rod. Impurities adhering to the brazing rod are disposed of by tapping the rod on the table.

Cooling

Following a brazing operation, move the torch flame over the surface of the metal on both sides of the braze for a considerable distance. This brings unequally heated sections of the base metal to an even heat. Small castings, or those which are preheated locally with a torch, should be covered with asbestos and allowed to cool slowly. If a preheating furnace is used, all draft openings should be closed and the top covered with asbestos to permit slow cooling in the furnace. No stress should be placed on a brazed joint until it has completely cooled. The finished deposit may be cleaned with a wire brush to remove any excess flux or oxides which may have risen to the surface.

General Procedures

1. Bevel the edges, as shown in figure 85.

2. Sandblast or sear the edges with a slightly oxidizing flame.

3. Set up the work, as shown in figure 85.

4. Apply flux to the rod and to the beveled surfaces of the joint.

5. Using an oxidizing flame, preheat the joint until the flux begins to form crystal beads.

6. Direct the flame at the root of the joint and hold the fluxed rod in the outer flame. When the base metal reaches red heat, add a small portion of the filler rod to the heated area and continue until the beveled edges are tinned.

7. Adjust the flame to neutral and finish brazing the joint by melting the surface of the first deposit and adding more filler rod to build up the joint, as shown in figure 85.

8. Check your work with the instructor.

Precautions

1. Have proper spacing at the root area and see that graphite carbon has been removed.

2. Do not overheat the base metal.

3. Use the proper flame for tinning and for finishing the joint.

Low carbon steels are easily brazed. The techniques and procedures are very similar to those employed when brazing gray cast iron.

Braze welding repairs on high-carbon and tool steels should be made only in case of an emergency and where the lower strength and hardness of the filler metal are acceptable.

Braze welding should never be used where the part is subjected to severe conditions or where the temperature is higher than 650°F. At temperatures ranging from 500°F to 650°F., the strength of the filler metal is greatly impaired.

QUESTIONS

Note: Answer all questions on a separate sheet of paper due to conservation of paper. DO NOT WRITE IN THIS STUDY GUIDE.

1. What is the main outstanding mechanical property of cast iron?

2. What is the advantage of brazing over fusion welding of ferrous castings?

3. What does the speed of tinning and the contour of the braze deposit indicate when brazing cast iron?

4. What property is produced by brazing ferrous castings in comparison to fusion welding?

5. The strength of a brazed casting is reduced when it is subjected to tempratures above ________°F.

6. What type of cast iron is used when weight and rigidity is required in a cast iron?

7. What type of furnace produces cast iron?

8. What are the three types of cast iron? Tell how each can be repaired.

9. How is each of the three types of cast irons manufactured?

10. How should cast iron be cooled after welding? Why?

REFERENCES

1. TO 34W4-1-5, Welding Theory and Application.

2. TO 34W4-1-7, Fluxes - Welding, Brazing, and Soldering Modern Welding Handbook (Chapter 16).

Metal and NDI Branch
Chanute AFB, Illinois

3ABR53131-SG-209

FUSION WELDING FERROUS CASTINGS

OBJECTIVES

After completing this study guide and classroom instruction, you will apply the fundamental principles and techniques of fusion welding cast iron.

INTRODUCTION

Fusion welding of cast iron is done by using the oxyacetylene torch to melt the joint edges while adding a cast iron filler rod.

INFORMATION

MANAGEMENT OF DEFENSE ENERGY RESOURCES

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FUSION WELDING CAST IRON

Gray cast iron is the only one of the ferrous castings which can be welded by the fusion method using the oxyacetylene flame. The weld, when properly made, has a fine grain structure and is soft and easily machined. The strength of the weld is usually greater than the base metal. The main difficulties encountered in welding this metal by the fusion method are the forming of hard spots and the control of expansion and contraction, which has a tendency to distort the casting or cause additional breaks.

Cast Iron Filler Rod

A cast iron filler rod, high in silicon and low in sulphur, phosphorous, and manganese, produces the best results. The filler rod serves several important functions. It supplies the metal necessary to fill the vee and reinforce the weld. When welding begins and the bottom and sides of the vee are being melted, the end of the rod should be held in the outer flame envelope. This prevents chilling the molten pool which would result in hard spots in the weld. The filler rod should be added to the weld by melting it in the pool of molten metal. The melted sides of the vee, which are thoroughly fused with the added filler rod, provide the necessary weld reinforcement.

Joint Preparation

Thoroughly clean the metal surrounding the break when preparing gray cast iron for welding. Grinding or sandblasting is effective in removing rust or a heavy coating of oxide. Grease or oil may be removed by a solvent. If the metal is heavier than 1/8 inch in cross section, bevel the edges to be welded in the same manner as for steel plate. Cracks or breaks in castings that cannot be removed for beveling may be chipped out with a round nose or diamond point chisel. They may also be ground out if a flexible shaft or portable grinder is not available. When castings are broken in several pieces and have no machined surfaces, two or three points along the break should be left untouched so that they can be used to maintain alignment of the edges. Depending upon the thickness of the metal, the V-bevel should extend to either 1/16 or 1/8 inch of the bottom of the break, as shown in figure 86. This shoulder will prevent rapid melting of the metal at the bottom edges. Prior to welding a crack that extends from the edge or from an opening in a casting, it is always advisable to drill a small hole through the casting near the visible end of the fracture. If the crack should start to spread when heat is applied,

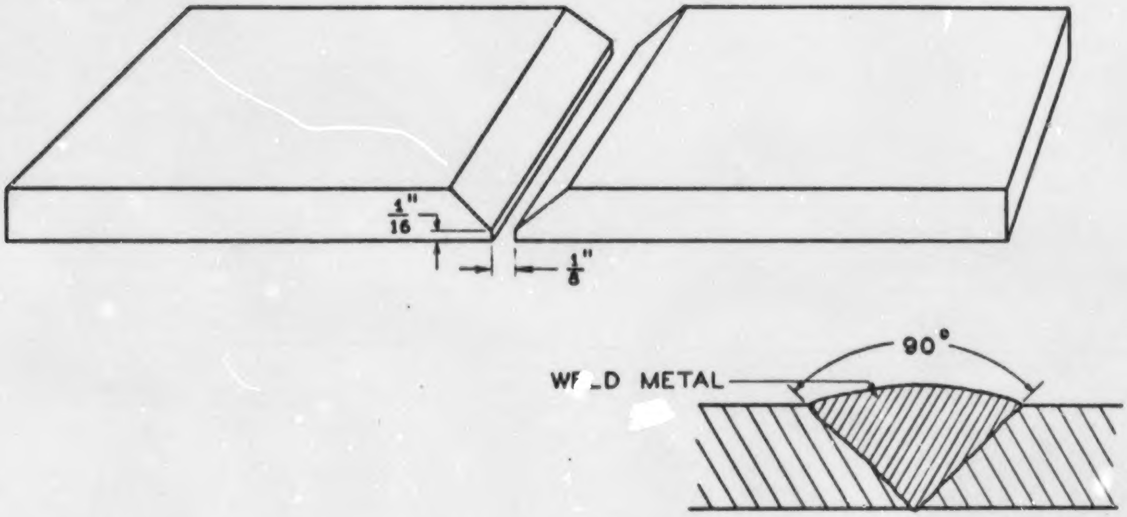

Figure 86. Cast Iron Butt Joint.

the small hole will prevent its spreading further.

Flame Adjustment

A neutral flame is used to fusion weld cast iron. Do not use a harsh flame. If the volume has to be turned up to ensure enough heat for fusion, either a larger torch tip is needed or the preheat was insufficient.

Torch Application

Generally, the torch tip used is slightly larger than the size ordinarily used for welding the same thickness of steel. With a large size tip there is less chance that the molten metal will be blown ahead onto the cold surfaces of the joint. However, care must be taken to prevent melting out of the bottom of the vee too rapidly. After the lowest part of the joint is welded, the larger tip will aid in speeding the completion of the weld.

Adjust the torch to a neutral flame since it has no chemical effect upon the composition of the metal. Hold the tip of the center cone approximately 1/8 to 1/4 inch away from the molten pool. The forehand method of welding may be used. However, for heavy sections, the backhand method is preferred. The backhand method aids considerably in controlling the molten pool and penetration is easier to obtain. A cast iron fusion welding flux is essential for producing satisfactory welds. The flux causes the oxides and impurities to float to the surface of the weld.

Procedures

1. Saw through the cast iron bar at a 45° angle.

2. Grind a 1/16" lip on the bottom edge, as shown in figure 86.

3. Adjust the flame for neutral and preheat each piece about 1" back of the beveled edges to a dull red.

4. Tack weld each end of the joint.

5. Using sufficient flux, finish the weld by either the forehand or the backhand method. Stir and puddle the molten pool continuously.

6. After the weld is completed, allow it to cool slowly.

7. Check your finished weld with the instructor.

Precautions

1. Be sure to preheat before starting to weld.

2. Make sure that the sides of the joint are melting and that fusion is taking place.

3. Stir and puddle the molten pool with the rod.

4. Use a sufficient amount of flux.

QUESTIONS

NOTE: Answer all questions on a separate sheet of paper due to conservation of paper. DO NOT WRITE ON THIS STUDY GUIDE.

1. How are gas pockets broken up when welding gray cast iron?

2. Why should the end of the filler rod be held under the outer flame envelope during fusion welding of cast iron?

3. Is it necessary to sear cast iron prior to fusion welding? Why?

4. What type of flame is used when fusion welding gray

4. What type of flame is used when fusion welding gray cast iron?

5. How far should the central cone be held from the molten pool of the base metal when welding gray cast iron?

6. What is the purpose of the flux when fusing ferrous castings?

7. How may grease or oil be removed from ferrous castings?

8. When a ferrous casting is broken, how can the pieces be aligned for fusion welding?

9. Why shouldn't the vee bevel extend to the bottom of the break?

REFERENCES

1. TO 34W4-1-5, Welding Theory and Application.

2. TO 34W4-1-7, Fluxes - Welding, Brazing, and Soldering, Modern Welding Handbook (Chapter 16).

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Chanute AFB, Illinois

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HARD SURFACING

OBJECTIVES

After completing this study guide and classroom instruction, you will identify the purpose, types, techniques of application, and mechanical properties of hard surfacing materials.

INTRODUCTION

The survival of any business depends upon the profits gained through the use of its equipment. If the service life of the equipment can be extended, the company has a better chance to survive. In the Air Force, hard surfacing is used to extend equipment service life, lower costs, and increase operating efficiency.

INFORMATION

MANAGEMENT OF DEFENSE ENERGY RESOURCES

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HARD SURFACING ALLOYS

Hard surfacing or "hard facing," refers to the process of applying extremely hard alloys to the surface of a softer metal in order to increase its resistance to wear, abrasion, corrosion, or impact. In most cases, hard surfacing alloys can be applied to a point, surface, or edge of any part by means of the oxyacetylene process. The wearing surface of drills, tools, cutters, or any other parts treated with these special alloys, will outwear the common steels 2 to 25 times, depending upon the type of hard surfacing alloy used and the service to which the part is subjected.

There are many types of hard surfacing alloys. Each alloy is specifically designed to provide properties which are best adapted to combat the destructive forces to be met in a given operation. In any type of mechanical operation, moving parts are subject to wear, resulting in loss of material. Hard surfacing reduces this wear. Hard surfacing alloys are widely used to protect new parts, to ensure greater efficiency, and to repair worn equipment. No one single hard surfacing material is satisfactory for all applications. Many types of hard facing alloys have been developed to meet the various requirements for hardness, toughness, shock, wear resistance, and other special qualities. These alloys are generally classified into five broad groups.

Group 1 Alloys

Alloys in this group consist mainly of an iron base and have less than 20 percent of alloying elements. These elements are mainly chromium, tungsten, manganese, silicon, and carbon. Group 1 alloys have greater wear resistance than any machine steel. Although not as hard as steel, they have greater toughness and shock resistance than any other hard facing alloys. They are used to build up badly worn sections before applying a final harder surfacing alloy of better grade. These alloys are used for rock crushing and similar equipment where resistance to shock and impact are more important than hardness.

Group 2 Alloys

The alloys in this group consist of an iron base having 50 to 80 percent iron with the remainder being elements used in Group 1. Small percentages of cobalt and nickel are sometimes added. Some of these alloys have the property of "red hardness" which is the ability to remain hard at a red heat. These alloys are used for final hard-wear resisting surfaces after the part has been built up with a high strength rod.

Group 3 Alloys

The alloys in this group consist of the nonferrous alloys, such as cobalt, chromium, and tungsten, as well as other nonferrous hard surfacing materials. Some of these alloys also have the property of red hardness. These alloys are available in different grades, which are all highly resistant to wear and possess a toughness and strength giving them a wide range of application. Valves made from these alloys are designed for handling gas, oil, acids, high temperatures, and high pressure steam. These alloys are used extensively for valve seats in internal combustion engines.

Group 4 Alloys

The alloys in this group consist of the so-called carbide materials or diamond substitutes. They are the hardest and most wear resistant of all the hard surfacing materials. Some of these alloys contain 90 to 95 percent tungsten carbide with the remainder being cobalt, nickel, iron, or similar metals. These give strength, toughness, heat resistance, and impact strength to the tungsten carbide. Some of these alloys are almost pure tungsten carbide and contain no alloying elements. Alloys of this group are furnished in the form of small castings. They are welded to the surface of the metal or other hard surfacing material. The application of tungsten carbide pieces to wearing surfaces is known as hard setting.

Group 5 Alloys

The alloys in this group consist of crushed tungsten carbides of various sizes. These may be fused to strips of mild or low alloy steel, embedded in hard surfacing material or high strength rod, or packed in mild steel tubes of various diameters. All of these are available in short lengths which may be applied to the wearing surface as welding rod. Crushed tungsten carbides are also available in loose form as granular pieces or powder and may be sprinkled on the wearing surface and melted into it. The alloys in this group, although more expensive than other types, are used for many applications because of their long life.

HARD SURFACING APPLICATIONS

Most metals and their alloys can be readily hard surfaced with the exception of copper, aluminum, and their alloys. These metals cannot be satisfactorily hard surfaced because of their low melting points. In some cases, heavy sections of brass, bronze, and copper can be hard surfaced by preheating to a red heat and then applying the Group 3 alloys. Hard surfacing alloys can be applied to the following metals and alloys:

1. Low and medium carbon steels with a carbon content of 0.50 percent or less.

2. High carbon steels, if they are heat treated before and after hard surfacing to remove hardness and brittleness to prevent cracking.

3. Low alloy steels, depending upon the base metal. Heat treatment is required after hard surfacing.

4. Manganese steels, which are hard surfaced by the metallic arc welding process. Care should be taken to apply the welding heat to the part uniformly, and to avoid overheating of the metal. Deposits should be peened to relieve cooling stresses.

5. Stainless steels, including the high chromium and chromium nickel steels. The physical properties of the particular steel should be known in order to maintain corrosion resistance after hard surfacing. Uniform heating and cooling help to prevent warping and cracking due to the higher coefficient of expansion of stainless steel.

6. Gray cast iron. Since the melting point of cast iron is lower

than steel, special precautions should be taken in working with thin sections.

7. Malleable iron. The malleable iron surface beneath the hard surfacing layer hardens. Some of this hardness can be removed by reheating the metal to approximately 1500°F.

Metal Preparation

The surface of the metal to be hard surfaced must be free of all scale, rust, dirt, and other foreign substances. This is done by grinding, machining, or chipping. When these methods are not available, the surface may be prepared by filing, wirebrushing, or sandblasting. The latter methods are not as satisfactory, since small particles of foreign matter which remain on the surface must be floated out during the hard surfacing operation. All edges of grooves, corners, or recesses must be well rounded to prevent overheating the base metal.

Preheating

The same precautions should be taken for preheating in hard surfacing as is done for welding the particular base metal. If possible, steels in the heat treated condition should be annealed before the hard surfacing layer is applied. Quenching in water will crack the hard surfacing layer. When it is necessary to heat the metal to the critical temperature after hard surfacing, oil should be used as the quenching media. When it is impossible, or undesirable, to anneal high carbon steel or high tensile low-alloy steel, the hard surfacing alloy is deposited by the transition bead method. This is done by first depositing a thin layer of stainless steel, such as the 25 percent chromium/20 percent nickel rod or the 18 percent chromium/8 percent nickel rod. Next, build up the section to approximately the original dimension, using 11 to 14 percent manganese or high strength rod and then finish by hard surfacing with one of the Group 2 alloys.

Flux

A flux is not required for applying a single layer of hard surfacing alloy by the oxyacetylene torch. However, in depositing the hard surfacing alloy in more than one layer, a flux helps to remove any scale and oxides formed on the preceding layer. This is particularly true when hard surfacing cast iron, in which case a cast iron welding flux is satisfactory. The film of flux formed on the molten pool reduces the rate of cooling of the deposited material; thus, permitting gas, oxides, and slag inclusions to come to the surface. This results in a hard and solid surface layer.

Deposit Thickness

Depending upon the specific application, worn sections are rebuilt with hard facing deposits ranging from 1/16 to 1/4 inch in thickness. When it becomes necessary to deposit hard surfacing material in excess of 1/4 inch, the part is rebuilt with the Group 1 alloys to within 1/16 to 1/4 inch of the finished size. The final deposit, consisting of Group 2 or 3 alloys, is added with some excess to permit grinding to the desired finished dimensions. When harder and more brittle Group 4 and 5 hard surfacing materials are applied, either as a final deposit or in a single layer, the shape of the deposit should be carefully controlled. This is important in order that impact or shock loads may be transmitted through hard surfacing metal into the tougher base metal. When corners, edges, or builtup sections are not backed up by tough base metal, they will chip or break off in service.

Flame Adjustment

Hard surfacing metal is applied by using a carburizing flame, as shown in figure 87. The exact amount of excess acetylene in the welding flame can be found by varying the acetylene during the initial deposit of the rod. The oxyacetylene flame allows a close control over the operation and produces a smooth deposit. The flame should be adjusted to produce a quiet pool and good flowing qualities for the particular hard surfacing material. Figures 88

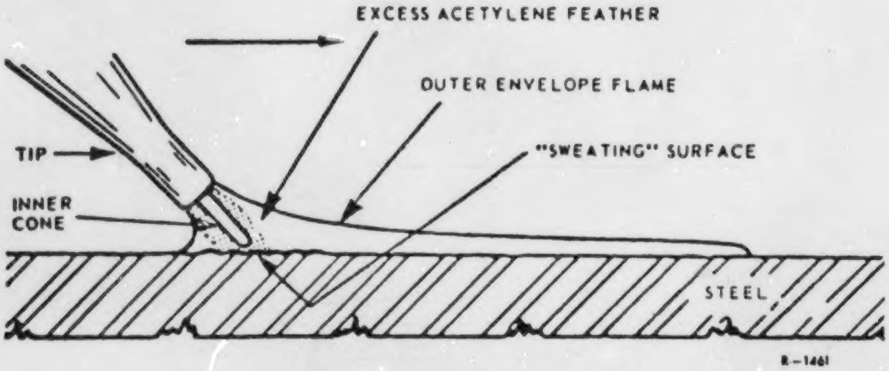

EXCESS ACETYLENE FEATHER
OUTER ENVELOPE FLAME
TIP
"SWEATING" SURFACE
INNER CONE
STEEL
R-1461

Figure 87. Type Flame and Tip Position to Use When Producing a "Sweating" Condition Prior to Hard Surfacing.

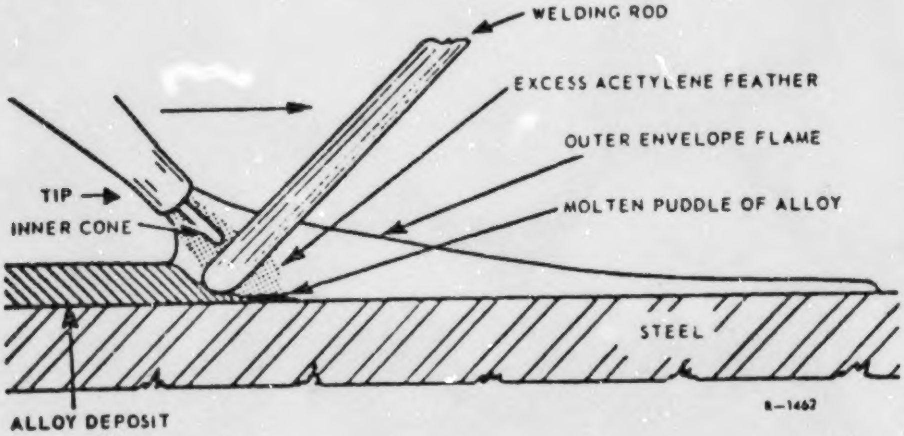

WELDING ROD
EXCESS ACETYLENE FEATHER
OUTER ENVELOPE FLAME
TIP
MOLTEN PUDDLE OF ALLOY
INNER CONE
STEEL
ALLOY DEPOSIT
R-1462

Figure 88. Forehand Method of Hard Surfacing.

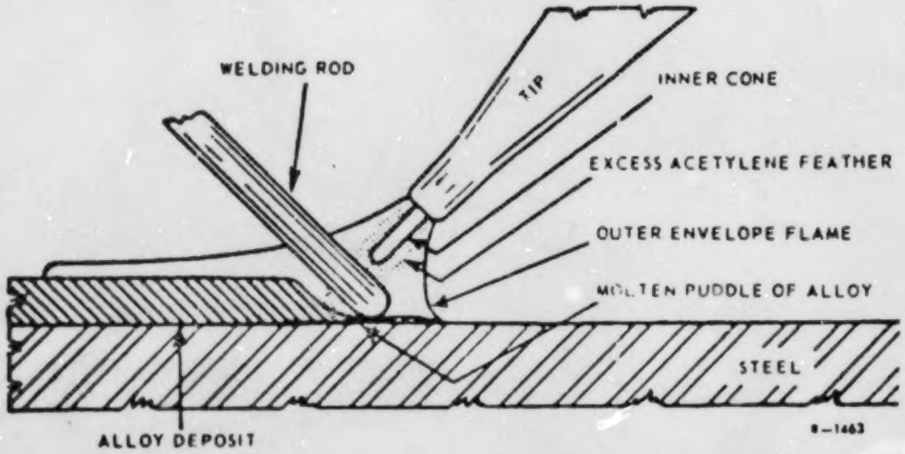

WELDING ROD
TIP
INNER CONE
EXCESS ACETYLENE FEATHER
OUTER ENVELOPE FLAME
MOLTEN PUDDLE OF ALLOY
STEEL
ALLOY DEPOSIT
R-1463

Figure 89. Backhand Method of Hard Surfacing.

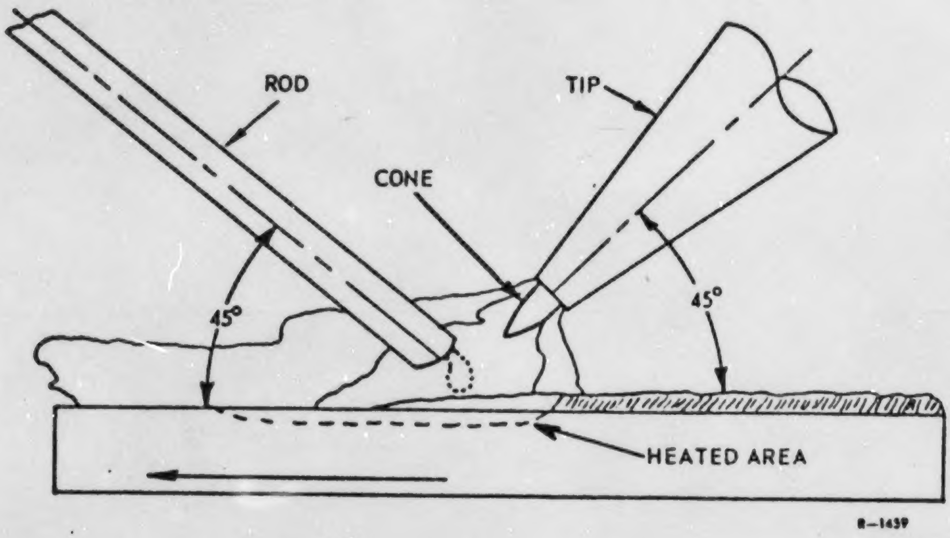


Figure 90. Hard Surfacing Material Being Applied With the Use of an Oxyacetylene Torch.

and 89 show the two methods of applying hard surfacing material. Particles of scale and foreign matter are easily eliminated by these methods and edges and corners are easily formed. This is particularly important when it becomes necessary to grind the hard surfacing deposit to close dimensional limits. The degree of penetration of the hard surfacing alloy in the base metal is accurately controlled by the flame. This is important since some of the alloys are puddled into the base metal while others are merely "sweated" onto the base metal, as shown in figure 90. When a thin edge is to be hard surfaced or a desired shape is to be built up with the hard surfacing materials, a copper mold or backup strip may be used. The tip size used for hard surfacing should be approximately two sizes larger than that required for welding metal of the same thickness.

Note in figure 90 that the puddle of molten metal is larger than the puddle used when making a weld. The outer flame area preheats the base metal in advance of the deposited surfacing metal. A carburizing flame is used for hard surfacing.

Procedure

1. Bevel the edges of the plate to a 60 degree angle, avoiding sharp edges.

2. Select and install the proper size tip.

3. Adjust the flame to soft carburizing.

4. If necessary, make the final adjustment of the flame during the first inch of weld.

5. Inspect for insufficient edge buildup and burned deposits upon completion of the weld.

6. Remove approximately one-half of the hard surfacing deposit and inspect for porosity.

7. Check your work with the instructor.

Precautions

1. Use a tip large enough to do the work.

2. Do not overheat and melt the base metal.

3. Use the proper flame.

QUESTIONS

Note: Answer all questions on a separate sheet of paper due to conservation of paper. DO NOT WRITE IN THIS STUDY GUIDE.

1. Why are all edges and grooves rounded when setting up a hard surfacing project?

2. What are five types of hard surfacing alloys and what is each type specifically designed for?

3. The main purpose for hard surfacing is to add what property?

4. What must be done to high carbon steels before hard surfacing?

5. What must be done to low alloy steels before hard surfacing?

6. What must be done to manganese steels after hard surfacing?

7. What alloys cannot be hard surfaced?

8. Which group has less than 20% of the alloying elements?

9. Which group can be used in the buildup of badly worn sections before a final overlay is applied?

10. What is the maximum amount of hard surface deposits that may be removed by grinding?

REFERENCE

1. TO 34W4-1-5, Welding Theory and Application.

2. Modern Welding Handbook (Chapter 20).

PREPARE THE MAN PROGRAMMED TEXT FUNDAMENTALS 102C

Technical Training

SHOP SAFETY

6 March 1969

13-5

CHANUTE TECHNICAL TRAINING CENTER (ATC)

Programmed Text 3ABR42133-101E-II, 11 April 1968.

Designed For ATC Course Use

OBJECTIVE

The objective of this program is to teach you proper safety procedures which you must observe on the job as a Repairman.

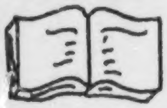
INSTRUCTIONS

This program presents information in small steps. Each page or "frame" contains an information panel and/or questions pertaining to information contained in the last information panel. Read the information presented within the solid-line box, then select the correct statement in response to the question asked in the question-mark outlined box. Read the questioning statement and then make your response after the appropriate question number on the answer sheet provided. MAKE NO MARKS IN THIS PROGRAM. The small step size of the information panel makes selection of the correct response an easy matter, and in most cases you won't have to be told the correct answer. However, the last page of this program contains a complete list of the correct response letters listed by question numbers. Feel free to consult this list at any time you are in doubt as to the correctness of any of your response choices.

DO NOT MARK IN THIS PROGRAM

INSTRUCTIONAL SYSTEMS DEVELOPMENT TEAM

3



The personnel in a shop are continually exposed to numerous hazards. Some activities are extremely hazardous; others which are nonhazardous can become hazardous due to carelessness, overconfidence, etc. Inexperienced personnel can sometimes create hazardous situations. Hazards are present during all normal activities, but their existence doesn't mean that an accident must occur. Our job is to prevent accidents, even under hazardous situations.

QUESTION 1.

? ?

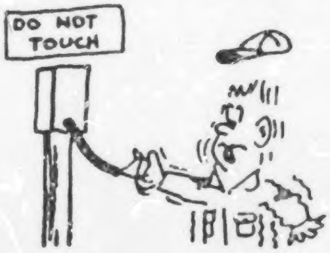
? Which of the statements below is most true? ?

? a. Personnel are subject to hazards in the ?
maintenance shop only when they become
? careless. ?

? b. Personnel are subject to hazards in a ?
maintenance shop during all normal activ-
? ities. ?

? ?

Frame 2.



Inefficiency, personal injury, and property damage are the results of accidents in the maintenance shop. In order to reduce this waste of time and money, prescribed safety standards must be observed by all personnel at all times.

QUESTION 2.

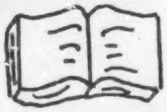
To promote efficiency and reduce the possibilities of personal injury and property damage, all personnel must

a. prevent accidents in the maintenance shop.

b. reduce waste in time and money.

c. observe prescribed safety standards.

.5



Some operations in a maintenance shop are hazardous to other operations within the shop. For instance, open welding could cause severe eye burn to personnel who look at the welding arc. Or, an explosion could occur if an acetylene torch is used where fuel vapors or paint fumes are present. For this reason painting, welding, and battery work will be accomplished in separate parts of the shop that are isolated from each other.

QUESTIONS 3 through 5.

? ?

3. Painting, welding, and battery work are isolated from each other in order to
   a. Prevent one operation from being hazardous to another.
   b. eliminate the hazards involved in each operation.

4. To prevent one operation from being hazardous to another the painting, welding, and battery work will be performed in
   a. the same shop.
   b. separate parts of the shop.

5. The painting, welding, and battery shops should be
   a. kept close together to minimize equipment duplication.
   b. isolated from each other.

? ?

Frame 4.

A major hazard in the maintenance shop is the possibility of fire due to the constant exposure of flammable fuels, lubricants, and other compounds. Also, parts, tools, work benches, and floors often become saturated with these flammable materials. Extreme care must be taken at all times to prevent shop fires from occurring under the conditions which always exist in any shop.

QUESTION 6.

? ?

? To prevent fires in the shop we see to it that ?

? ?

? a. no flammable materials are exposed in the shop area. ?

? b. Parts, tools, work benches, and floors don't become saturated with flammable materials. ?

? c. extreme care is exercised at all times. ?

? ?

7

Some prescribed safety standards which must be observed for the prevention of shop fires are:

a. Only explosion-proof electrical equipment and fixtures will be used in the paint shop.

b. Use of flame-producing equipment will not be permitted in the shop except in specified areas, such as the welding shop, where the required safety controls exist.

c. Smoking will be permitted in designated smoking areas only.

QUESTIONS 7 through 9.

? ?

Indicate whether the following statements are TRUE or FALSE.

7. Electrical equipment and fixtures in the paint shop must be flame-producing.

a. TRUE

b. FALSE

8. The use of flame-producing equipment is permitted only in areas where the required safety controls exist.

a. TRUE

b. FALSE

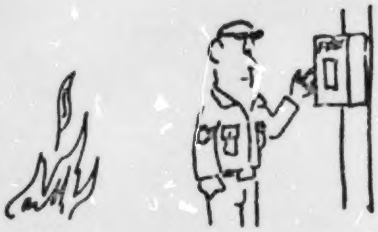
9. Smoking is not allowed except in designated smoking areas.

a. TRUE

b. FALSE

? ?

Frame 6.



If a fire should occur in your shop, be sure that a valid alarm is turned in. A valid alarm is one which tells responsible people, equipped to fight fires, the location of the fire and the name of the person turning in the alarm. Don't fail to turn in an alarm because you think the fire is too small. After the alarm has been turned in, use your best judgement to decide on whether to clear the building or attempt to extinguish the fire.

QUESTION 10.

? ?

? In case of fire in the shop, you should ?

? a. clear the building of as much equipment as possible. ?

?

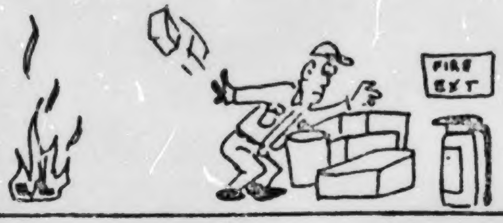
? b. yell "FIRE" and make sure that everyone is out. ?

? c. turn in an alarm. ?

? ?

Frame 7.

9



The importance of fire extinguishers being kept in good working order and being conveniently located throughout the maintenance shop cannot be overstressed. Their location will be clearly marked and kept free of obstructions at all times. They must be placed where they can be easily reached but where they cannot be accidentally bumped by personnel or equipment.

QUESTIONS 11 and 12.

? ?

? 11. Where will fire extinguishers be located? ?

? a. Anywhere handy. ?

b. Away from personnel and equipment.

? c. Where they can be easily reached but not in the way of personnel and/or equipment. ?

? 12. How will fire extinguisher locations be kept? ?

? a. No special way as long as they can be seen. ?

? b. Clearly marked and free of obstructions. ?

? c. Clean and free of grease and oil. ?

? ?

10

Frame 8.

Now, we are going to see how much you have learned so far about Shop Safety. Indicate whether each of the 10 following statements (on this and the next page) are either TRUE or FALSE.

? ?

13. The normal activities of a repair shop present numerous hazards to maintenance personnel.

    a. TRUE

    b. FALSE

14. Prescribed safety standards must be observed by all personnel in order to promote efficiency and reduce the possibility of personal injury and property damage.

    a. TRUE

    b. FALSE

15. Painting, welding, and battery work is accomplished in separate parts of the shop to prevent one operation from being hazardous to another.

    a. TRUE

    b. FALSE

16. Fire hazards exist in a shop due to the exposure of flammable materials and the saturation of parts, tools, work benches, and floors with flammable materials.

    a. TRUE

    b. FALSE

17. The electrical equipment and fixtures used in Air Force paint shops must be explosion-proof.

    a. TRUE

    b. FALSE

18. Flame-producing equipment must be used only in specified areas, such as the welding shop, where required safety controls exist.

    a. TRUE

    b. FALSE

? ?

CONTINUED ON NEXT PAGE

19. Smoking in the shop is forbidden except in designated areas.
    a. TRUE
    b. FALSE

20. Never attempt to extinguish a fire without turning in an alarm first.
    a. TRUE
    b. FALSE

21. Fire extinguisher locations will be clearly marked and kept free of obstructions.
    a. TRUE
    b. FALSE

22. Fire extinguishers will be placed where they can be easily reached, but cannot be accidentally bumped by personnel or equipment.
    a. TRUE
    b. FALSE

Frame 10.

Another dangerous and often unnecessary fire hazard is created by the fueling of equipment inside the shop. As an added precaution against fire, equipment will not be fueled inside the shop as a routine practice. They may be fueled inside, however, under controlled conditions but then only when approved by the Installations Fire Marshall.

QUESTION 23.

? ?

? When may equipment be fueled inside the maintenance shops? ?

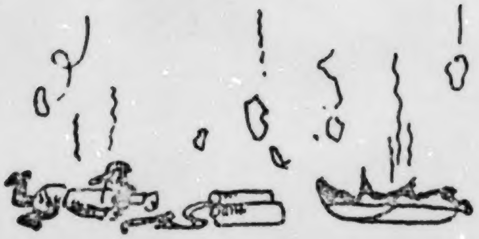
? ?

? a. Anytime, unless a directive from the Installations Fire Marshall prohibits it. ?

? b. Only under controlled conditions and then only on approval of the Installations Fire Marshall. ?

? c. Whenever necessary as a routine practice. ?

? ?



Working on fuel tanks is always a hazardous task. Explosions from fuel vapors can occur very easily. Before welding or other heat-producing work is done on gas tanks and other fuel containers, they should be drained, flushed out with water and, when practicable, filled with water. Filling with water will eliminate the danger of explosion and fire from fuel vapor inside the tank.

QUESTION 24.

? ?

? Before welding a fuel tank of any kind, it must be ?

? ?

a. filled with water.

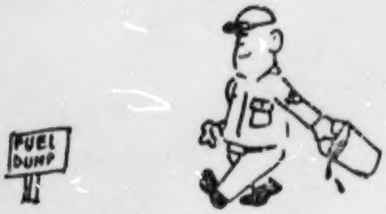
? ?

b. drained, flushed and, when practicable, filled with water. ?

? ?

Frame 12.

14



Another fire hazard which must be avoided is the one created when used oil, fuel, or other flammable liquids are poured into floor drains. An explosion hazard from vapors is created not just in **your** own building but in all other buildings through which the drain system runs. To prevent this hazard, flammable liquids will be put in metal containers which, when full, will be carried to some remote area and dumped.

QUESTION 25.

? ?

? The proper disposal of used flammable liquids is accomplished by ?

?

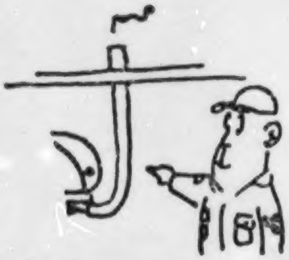
a. flushing them down the floor drain system.

?

b. carrying them to a remote area to be dumped.

?

? ?



Such areas as battery rooms, paint booths, and confined welding areas are subject to the accumulation of dangerous gases and vapors. To prevent personnel from being overcome by fumes, and to prevent explosions in these areas, special exhaust systems will be provided and used.

QUESTIONS 26 and 27.

? ?

26. Accumulation of dangerous gases and vapors is kept to a minimum in confined areas by

   a. keeping all doors and windows open.

   b. not performing any operations which may generate any dangerous gases or vapors inside.

   c. use of special exhaust systems.

27. Special exhaust systems are used in confined welding areas, battery rooms, and paint booths

   a. because the heat produced in these areas is dangerous.

   b. to eliminate the smelly fumes.

   c. to prevent the accumulation of dangerous vapors and gases.

? ?

16

Frame 14.

Equipment slipping off jacks, faulty hoisting devices, and fires are some of the personnel hazards you will encounter in the shop. The most common personnel hazard, however, is carbon monoxide gas. This is a poisonous gas which cannot be easily detected because of its colorless and odorless characteristics. Carbon monoxide gas is discharged from the engine through the exhaust system. Flexible tubing must be attached to the exhaust pipe to carry the fumes directly to the outside area of the shop.

QUESTIONS 28 and 29.

? ?

28. To help eliminate the possibility of carbon monoxide poisoning in a maintenance shop, you will

   a. never operate an internal combustion type engine inside the shop.
   b. direct the exhaust fumes outside the shop through a flexible tube that is attached to the engine exhaust pipe.

29. The most common personnel hazard in a maintenance shop is

   a. equipment slipping off jacks.
   b. faulty hoisting devices.
   c. fire.
   d. carbon monoxide gas.

? ?

17

General exhaust ventilation should be provided and used to prevent any accumulation of carbon monoxide gas inside the shop. These accumulations could come from engine exhaut manifold leaks, defective mufflers, or vehicles entering and leaving the shop.

QUESTION 30.

? ?

General exhaust ventilation will be provided and used in the maintenance shop in order to

a. prevent carbon monoxide from any source from accumulating in the shop.

b. allow the running of engines without directing the fumes outside the shop.

? ?

Remember, safety depends on you. If you know the safe procedures but do not practice them, you are at fault. On the other hand, you cannot practice safety if you don't know what the prescribed safety standards are. Our job is to teach you these standards. The rest is up to you.

Frame 16.

Let's stop again and review some of the things we've covered so far. Indicate whether each of the 6 following statements are TRUE or FALSE.

QUESTIONS 31 through 36.

? ?

31. The most common personnel hazard in the maintenance shop is fire.

a. TRUE

b. FALSE

32. Before welding on a gas tank it must be drained and flushed.

a. TRUE

b. FALSE

33. Vehicles may be fueled inside the shop under controlled conditions unless a directive from the Installation FIRE MARSHALL prohibits it.

a. TRUE

b. FALSE

34. Flammable liquids should never be drained into floor drains.

a. TRUE

b. FALSE

35. Battery rooms, painting booths, and confined welding areas will be provided with special exhaust ventilation.

a. TRUE

b. FALSE

36. Flexible tubing must be attached to the vehicle's exhaust whenever the equipment's engine is run inside the shop.

a. TRUE

b. FALSE

? ?

Frame 17.

Good housekeeping is essential to the safety and efficiency of shop operations. Imagine a shop with nothing in its right place, floors cluttered with junk, and oil and grease spilled all over the place. You wouldn't get much work done because of all the tripping and slipping you would be doing, and the chances are that you would wind up in the hospital with a serious injury.

QUESTION 37.

? ?

? Safe shop operation depends on ?

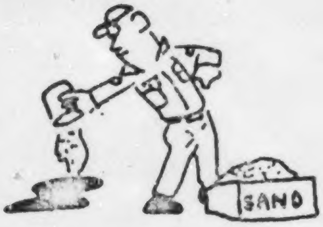
? a. using personal protective equipment. ?

? b. good housekeeping. ?

? c. applying only those shop safety practices ?
necessary to keep the inspectors off your
? back. ?

? ?

Frame 18.



Shop floors will be kept clean and free of oil, grease, gasoline, water, and other hazardous or slippery material. Boxes of sand or other suitable absorbent materials will be provided to use on spilled grease and oil. After the absorbent material has been applied to spills, the floor will be thoroughly cleaned.

QUESTION 38.

? ?

? To clean up a grease or oil spill, you will use ?

? a. sand or other absorbent material. ?

? b. a rag dipped in solvent. ?

? ?

Frame 19.

There are many hazardous operations which must be performed continually in the maintenance shop. To make these operations less hazardous, the Air Force provides the best personal protective equipment available. You are responsible for using this equipment. Personal protective equipment includes such items as face shields, impact goggles, rubber and asbestos gloves, chemical goggles, welding helmets, aprons, etc. This equipment will be kept in good condition and will be conveniently located for immediate use.

QUESTION 39.

? ?

? The Air Force provides personal protective equipment in the maintenance shop to ?

? ?

? a. eliminate the possibility of an accident while performing hazardous operations. ?

? b. make operations less hazardous. ?

? ?

Frame 20.

When working with batteries in the battery shop, personnel must be careful to wear the prescribed personal protective equipment. Battery acid, spilled on your clothing will "eat" holes in them and, if splashed in your eyes, could blind you permanently.

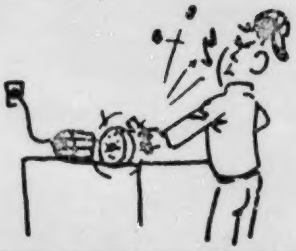
QUESTION 40.

? ?

? To protect your eyes and clothing while working ?
with batteries, you must wear
? ?
a. impact goggles, steel-toed shoes, and
? asbestos gloves. ?

? b. chemical goggles, rubber gloves, and a rubber apron. ?
? ?

? ?



Your eyes are your most valuable asset and they must be constantly protected against injury while working in the maintenance shop. When using a grinding wheel or cutting wheel which produces flying chips or dust, impact goggles or a face shield must be worn. You also need protection from dirt entering your eyes while working on your back under equipment.

QUESTION 41.

? ?

? You must wear goggles or a face shield to protect ?
your eyes when
?   ?
a. using a grinding wheel or cutting device
? which produces chips or dust. ?

? b. working under equipment ?

? c. both "a" and "b" above. ?

? d. neither "a" nor "b" above. ?

? ?

Frame 22.

The things we have covered so far have been in a variety of areas but, then, shop safety is a big order and includes several areas we cannot even cover in this program. Safety is a continuousthing. You may get by for a while neglecting the rules for safety, but sooner or later it can happen - serious injury or even death.

QUESTION 42.

? ?

? Safety in the maintenance shop is dependent on ?

? a. good common sense. ?

? b. constant obedience to prescribed safety standards. ?

? ?

c. good housekeeping.

? ?

d. all of the above.

? ?

? ?

2.

25

Let's move into the area of personal clothing. The type of clothing you wear on the job is very important. Your clothes should be of a good comfortable fit but not too loose. Loose clothing is easily caught on machinery and may cause serious injury. Neckties, rings, and other jewelry will not be worn for the same reasons. Clothing which has become saturated with flammable substances will not be worn or stored in lockers as this constitutes a fire hazard. The job itself will determine how often you should change. Here again, good common sense must be used.

QUESTION 43.

? ?

? Why must loose clothing, rings, or other jewelry ?
not be worn while working on or around equipment?
? ?

? a. They can be easily caught on machinery and other equipment causing serious injury. ?

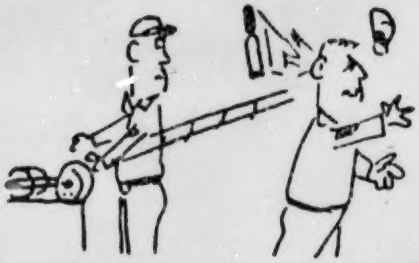
? b. To keep from damaging machinery and equipment. ?

? ?

? ?

Frame 24.

26



Shop machinery which performs operations under power can be dangerous. The point of operation where the machine does its work, as well as gear trains, shafts, belts, drives, chain and sprocket drives must all be guarded according to standards set forth in the Ground Safety Manual. Machine guards are put in place for your protection. They will not be removed or blocked out of the way under any circumstance.

QUESTIONS 44 and 45.

? ?

44. Machine guards may be removed or blocked

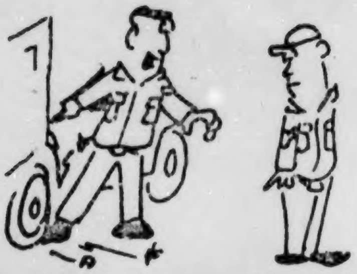
- a. whenever necessary to get maximum utilization of the machine.
- b. only on approval of the maintenance officer for specific jobs.
- c. never during operation.

45. What is the reason for having machine guards on machinery in the maintenance shops?

- a. To prevent damage to the machine.
- b. To protect personnel from injury.
- c. Both "a" and "b" above.
- d. Neither "a" nor "b."

? ?

27



A very important piece of equipment used in the maintenance shop is the equipment lift or hoist. Its purpose is to raise the equipment so that personnel can work underneath. Needless to say, all such lifts must be equipped with a safety device to prevent unintentional or accidental lowering.

There are two types of lifts commonly used. One is the roll-on or drive-on type; the other is the frame contact or chassis-lift type. All roll-on type lifts will be equipped with stop chocks, preferably automatic, which spring into place when the equipment enters the lift.

QUESTIONS 46 and 47.

? ?

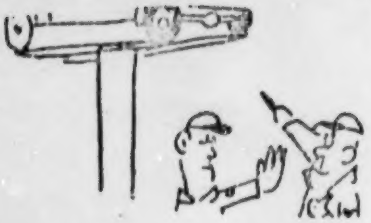
46. What safety feature must all equipment lifts be equipped with?
    - a. Stop chocks which prevent the equipment from moving while on the lift.
    - b. A device which prevents accidental lowering of the lift.

47. What additional safety features must all roll-on type lifts be equipped with?
    - a. Non-skid paint.
    - b. Side rails.
    - c. Stop chocks.
    - d. Safety leg.

? ?

Frame 26.

28



No person will be permitted to remain with the equipment on the lift, when it is on a lift that is moving or is elevated.

QUESTION 48.

? ?

? When will persons be permitted to remain with the equipmetn on moving or elevated lifts. ?

a. Only when the engine is running.

b. Only if the engine is not running.

c. During brake bleeding operations.

d. Not under any circumstance.

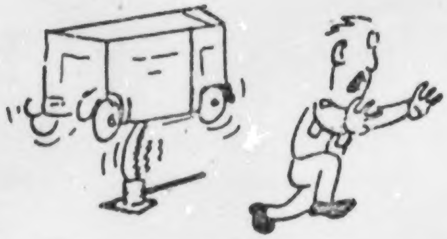
? ?

21.

You must inspect a lift for proper operation and condition prior to raising equipment; that is, determine if all safety devices are working properly.

However, when using a jack for lifting equipment there are still more safety precautions that must be observed.

Frame 28.



When using a jack you must be sure that it has a rated capacity sufficient to lift and sustain the load. That is, make sure that the jack is not too small for the job. All jacks, except those supplied by the manufacturer as standard equipment, will be stamped with their rated capacity in a prominent location on the jack. Once the equipment has been raised by a jack the equipment must be securely blocked up with "jack stands" to prevent its falling. Even after the equipment is jacked up and securely blocked, you will not place any part of your body directly under the wheels of the equipment.

Frame 29.

QUESTIONS 49 through 52.

? ?

Indicate whether each of the 4 following statements is TRUE or FALSE.

49. All jacks except standard-equipment jacks must be stamped with their rated capacity.

a. TRUE

b. FALSE

50. The rated capacity of a jack is the amount of weight it will lift and sustain safely.

a. TRUE

b. FALSE

51. If the jack is rated to sustain the weight of equipment safely there is no need of securely blocking up the equipment after it has been jacked.

a. TRUE

b. FALSE.

52. You will not place any part of your body directly under the wheels of securely blocked equipment.

a. TRUE

b. FALSE

? ?

Frame 30.

We have said that good housekeeping is essential to safe shop operations. Answer these questions.

QUESTIONS 53 through 58.

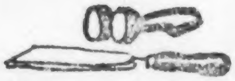
? ?

53. How should spilled grease or oil on the shop floor be taken care of?

a. Apply absorbent material to the spill and clean it up thoroughly.

b. Wipe it up with a solvent-soaked rag.

c. Flush it down the floor drain.



54. Impact goggles should be worn when

a. working under equipment.

b. doing engine tune-up operations.

c. working in the battery room.

d. sharpening a chisel on a grinder.

55. You must remove all rings and other jewelry when working on any equipment in the maintenance shop.

a. TRUE

b. FALSE

56. Machine guards may be removed or blocked out of the way when they prevent using the machine for special operations.

a. TRUE

b. FALSE

57. All jacks must be equipped with

a. stop chocks.

b. a safety leg or other device which will prevent accidental lowering.

c. side rails.

58. The rated capacity of a jack is

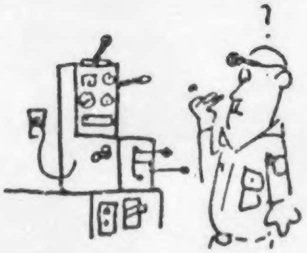
a. the amount of weight the jack will lift and sustain safely.

b. always stamped prominently on the jack except for jacks which come as standard equipment.

c. both "a" and "b" above.

d. neither "a" nor "b."

? ?



The modern Air Force maintenance shop is equipped with many kinds of power tools to make your job faster and easier. To use these tools requires some knowledge about their safe operation. For example, when using electrical power tools, always make sure that they are grounded. Serious electrical shock could result from using any ungrounded electrically-operated tools.

QUESTION 59.

? ?

? Electrical power tools must be ?

? a. equipped with insulated handles. ?

? b. of the same voltage as the equipment being worked on. ?

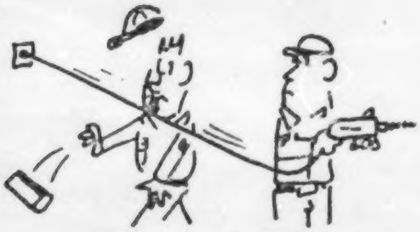
?

c. grounded. ?

? ?

? ?

Frame 32.



When using portable electrical tools, it is sometimes necessary to use extension cords or cables. Drop lights are often used in areas which need additional light. An example of this would be when you were working underneath equipment. The mechanic using portable electrical tools and lights will not string cords or cables carelessly across the shop floor. Serious tripping accidents can result.

QUESTION 60.

? ?

? When using electrical tools and equipment, you must ?

?

a. be sure that they are grounded. ?

?

b. not create a hazard with electric cables and cords carelessly strung across the shop. ?

? ?

c. both "a" and "b" above. ?

?

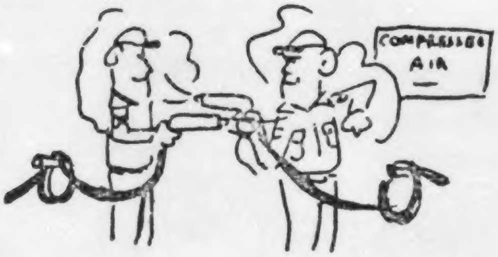
d. neither "a" nor "b." ?

? ?

? ?

35

Frame 33.



Some power tools used in the maintenance shop, such as impact wrenches and air drills, are operated by compressed air. Air may also be used for cleaning debris from a repair job, paint spraying, and airing up tires. Compressed air is dangerous and must be used with caution at all times. It will never be directed at a fellow worker.

QUESTION 61.

? ?

? Compressed air will never be used for ?

? a. cleaning parts. ?

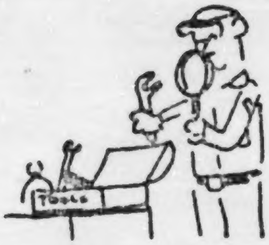
? b. horseplay. ?

? c. both "a" and "b" above. ?

? d. neither "a" nor "b." ?

? ?

Frame 34.



Each mechanic in a maintenance shop will be issued a tool kit for his own personal use. It will be his responsibility to look after these tools and keep them in top shape. Tool kits will be inspected periodically and any defective tools will be replaced immediately. A defective tool could cause serious injury. The Air Force is more than glad to replace your defective tools if doing so will prevent any lost time or injury.

QUESTIONS 62 through 65.

37

? ?

? 62. In the interests of safety, tool kits will be ?

? a. turned in for inspection once a month. ?

? b. inspected and defective tools repaired once a week. ?

? c. inspected periodically and defective tools replaced immediately. ?

?

? 63. All electrically-powered equipment and tools must be effectively grounded to prevent electrical shock to the operator. ?

?

? a. TRUE ?

? b. FALSE ?

?

? 64. Extension cords or cables will not be used with portable electric tools because they are a tripping hazard. ?

? a. TRUE ?

? b. FALSE ?

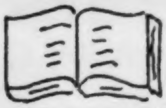
? 65. Defective tools will be replaced immediately. ?

? a. TRUE ?

? b. FALSE ?

? ?

Frame 36.



One more thing! The maintenance shop is a busy place. Equipment is constantly on the move. All personnel are moving about in the course of their normal duties. To protect personnel, a maximum speed limit of 5 MPH will be enforced in and around the shop. All vehicles entering or leaving the shop will signal with their horn to warn personnel of on-coming traffic.

QUESTIONS 66 and 67.

? ?

? 66. The maximum speed limit in and around the maintenance shop is ?

?

a. 3 MPH. ?

b. 5 MPH. ?

c. 10 MPH. ?

? 67. When entering or leaving the maintenance shop, vehicle operators must ?

?

a. look and proceed with caution. ?

b. sound horn and proceed with caution. ?

c. maintain a speed of at least 5 MPH. ?

? ?

REMEMBER: It's not enough to just learn the prescribed safety standards, you must also practice them constantly.

If you turned here, looking for the list of correct answers, you will find them printed on the next (last) page.

40

Frame 38.

Response Confirmation Panel

Question Number	Correct Answers	Question Number	Correct Answers
1.	b.	35.	a.
2.	c.	36.	a.
3.	a.	37.	b.
4.	b.	38.	a.
5.	b.	39.	b.
6.	c.	40.	b.
7.	b.	41.	c.
8.	a.	42.	d.
9.	a.	43.	a.
10.	c.	44.	c.
11.	c.	45.	b.
12.	b.	46.	b.
13.	a.	47.	c.
14.	a.	48.	d.
15.	a.	49.	a.
16.	a.	50.	a.
17.	a.	51.	b.
18.	a.	52.	a.
19.	a.	53.	a.
20.	a.	54.	d.
21.	a.	55.	a.
22.	a.	56.	b.
23.	b.	57.	b.
24.	b.	58.	c.
25.	b.	59.	c.
26.	c.	60.	c.
27.	c.	61.	b.
28.	b.	62.	c.
29.	d.	63.	a.
30.	a.	64.	b.
31.	b.	65.	a.
32.	a.	66.	b.
33.	b.	67.	b.
34.	a.		

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PREPARE THE MAN

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3AZR53151-HO-101
3AZR53151-1-HO-101
3AZR53151-2-HO-101

Technical Training

Metals Processing Specialist
Heat Treatment and Electroplating of Metals
Welding of High Performance Aircraft and Missile Systems
Welding High & Low Pressure Lines

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1 July 1975

13-5

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Chanute AFB, Illinois

3ABR53230-HO-100
8 June 1970

METALS PROCESSING SPECIALIST
GLOSSARY OF TERMS

AC or ALTERNATING CURRENT--Electric current which reverses its direction every cycle.

ACETYLENE--Gas composed of two parts of carbon and two parts of hydrogen; it produces one of the highest temperatures obtainable in burning gases (6300°F).

ACETYLENE REGULATOR--Automatic valve used to reduce cylinder pressures to torch pressures and to keep these pressures constant.

ALLOY--Intimate mixture of two or more metals.

ANNEALING--To soften metals by heat treatment.

ARC--Flow of electricity through a gaseous space or air gap.

ARC BLOW--Magnetic pull which causes the arc to wander toward the pull.

ARC LENGTH--Distance from the end of the electrode to the work surface.

ARC VOLTAGE--Voltage across the welding arc.

ARC WELDING--Fusing two metals together with an electric arc.

BACKING--Material used to back up the joint during welding, such as copper, bronze, etc.

BARE ELECTRODE--Arc filler rod without a coating.

BASE METAL--Metal to be welded.

BEAD--The finished weld.

BLOW PIPE--Oxyacetylene torch.

BRAZING--Type of soldering in which brass is used.

BURNING--Violent combination of oxygen with any substance which produces heat.

BUTT WELD--Weld in which the two pieces of metal to be joined are placed in the same plane.

CARBON--Element which is combined with iron to form various kinds of steel.

CARBURIZING--Addition of carbon to any metal.

OPR: TSDT
DISTRIBUTION: X
TSDT - 200; TSOC - 2

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COATED ELECTRODE--Arc filler wire with a coating on it, commonly called flux.

CRACKING--Opening a valve slightly.

CRATER--Indentation at the end of a weld.

CASE HARDENING--Adding carbon to the surface of a mild steel.

CASTINGS--Metal forms produced by pouring molten metal into a shaped container.

DC or DIRECT CURRENT--Electric current which flows only in one direction.

DEPTH OF FUSION--Distance from the surface of the base metal to that point at which the fusion ends.

ELECTRODE--The point in the circuit at which the arc begins to form.

FACE OF WELD--Exposed surface of a weld.

FILLER ROD--Metal wire that is melted and added to the welding puddle.

FILLET WELD--Filling in with weld metal between two surfaces.

FLASH--Electric arc rays which are harmful to the human eye.

FLAT WELD--Horizontal seam weld on a horizontal surface.

FLUX--Chemical used to promote fusion of metals.

GAS POCKET--Cavity or opening within a weld caused by trapped gases.

GENERATOR--Machine which generates or produces gas or electricity.

HEAT AFFECTED ZONE--Area along all sides of a weld that has been affected by heat.

HELMET--Protecting hood which fits over the arc welder's head.

HORIZONTAL WELD--Horizontal seam weld on a vertical surface.

HOSE--Flexible tube used to carry gases from the regulator to the torch.

LAP JOINT--Joint formed by two overlapping pieces of metal.

LAP WELD--Welding in which the edges of the two metals lap one over the other.

LENS--Specially treated glass through which one may look at an intense flame without being injured by the harmful rays.

MIXING CHAMBER--That part of a welding torch in which the welding gases are mixed.

NEGATIVE CONNECTIONS--Connections in an electric circuit through which the current flows back to its source.

ORIFICE--Restricted opening through which gases flow.

OXIDIZING--Combining oxygen with any substance.

OXIDIZING FLAME--Excess of oxygen in the torch mixture.

OXYGEN ACETYLENE CUTTING--Cutting metal using the oxygen jet which is incorporated with an oxygen-acetylene, pre-heating flame.

OXYGEN--Gas which actively supports combustion.

OXYGEN-ACETYLENE WELDING--Method of welding, using a combination of the two gases--oxygen and acetylene.

OXYGEN REGULATOR--Automatic valve used to reduce cylinder pressures to torch pressures.

PEENING--Mechanical working of the metal by means of a hammer.

PENETRATION--Distance the fusion zone extends into the surface of the metal.

POROSITY--Gas pockets or voids in metal.

POSITIVE CONNECTIONS--Connections in an electric circuit out of which current flows.

POST HEATING--Heat applied to the work after welding.

PUDDLE--Molten pool.

SLAG--Undesirable material trapped in weld metal.

SPATTER--Metal particles put off during welding.

TINNING--Soldering in which the metals to be soldered together are first given a coating of the soldering metal.

TIP--End of the torch at which the gas burns, producing a high temperature flame.

TORCH--Mechanism which applies the heat during welding.

VERTICAL WELD--Vertical seam weld on a vertical surface.

WELD--Joining of two pieces of metal by fusion.